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Excavations at the Lower Palaeolithic site at Elveden, Suffolk, UK

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The Lower Palaeolithic site at Elveden, Suffolk, was the subject of new excavations from 1995–1999. Excavations around the edge and in the centre of the former clay-pit revealed sediments infilling a lake basin that had formed in Lowestoft till, overlying Chalk, the till being attributed to the Anglian glaciation (MIS 12). The lake sediments contain pollen that can be assigned to pollen zones HoI and HoIIa of the early Hoxnian (MIS 11). Overlying grey clays contain ostracods, molluscs, vertebrates, and carbonate concretions. Together they are indicative of a fluvial environment in a temperate climate. AAR ratios (amino acid racemisation) on the molluscs also suggest correlation with MIS 11. Further indications of a fluvial context are indicated by thin spreads of lag gravel along opposite sides of the clay-pit, marking the edges of a channel. The gravel forms the raw material for the human industries which consist of handaxes, flake tools, flakes, and cores. Further artefacts are found in the overlying black clay, which is interpreted as a palaeosol that formed with the silting-up of the channel. The basin was further infilled with colluvial 'brickearths', which also contain artefacts that are probably derived from the underlying gravel. Further evidence of soil formation was identified in the 'brickearth'. Coversands with periglacial involutions overlie the 'brickearth' at the top of the sequence. These probably formed in the last cold stage, the Devensian (MIS 5d–2).

INTRODUCTION AND HISTORY

(NA, SL & SP)

The Brickyard Pit at Elveden, Suffolk (TL 809 804), is situated 3.5 km to the west-south-west of Thetford.

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The site lies on the eastern edge of an area once known as Elveden Warren, now occupied by the *Center Parcs* holiday village. The old pit is just to the north of the main entrance of the village. The locality forms part of the Breckland, an area of north-western Suffolk and south-western Norfolk characterised by a low plateau, typically 30–50 m OD, but rising in places above that. The Breckland is dissected by a number of rivers (including the Rivers Lark, Little Ouse and the Wissey) which drain the Breckland westwards into the Fen basin (Fig. 1).

The pre-Quaternary geology consists of eastward-dipping Cretaceous Upper Chalk, with Upper Jurassic Oxford Clay and Gault to the west. There is a discontinuous cover of Quaternary sediments over the region. These consist mainly of chalky tills and associated glaciofluvial deposits. The Breckland is also covered by extensive but thin coversands, giving rise to the typically sandy heathland soils (Chorley *et al.* 1966; Corbett 1973). The coversands are mainly of Late Pleistocene age, but sporadic deposition of wind-blown sands has taken place during the Holocene (Bateman & Godby 2004).

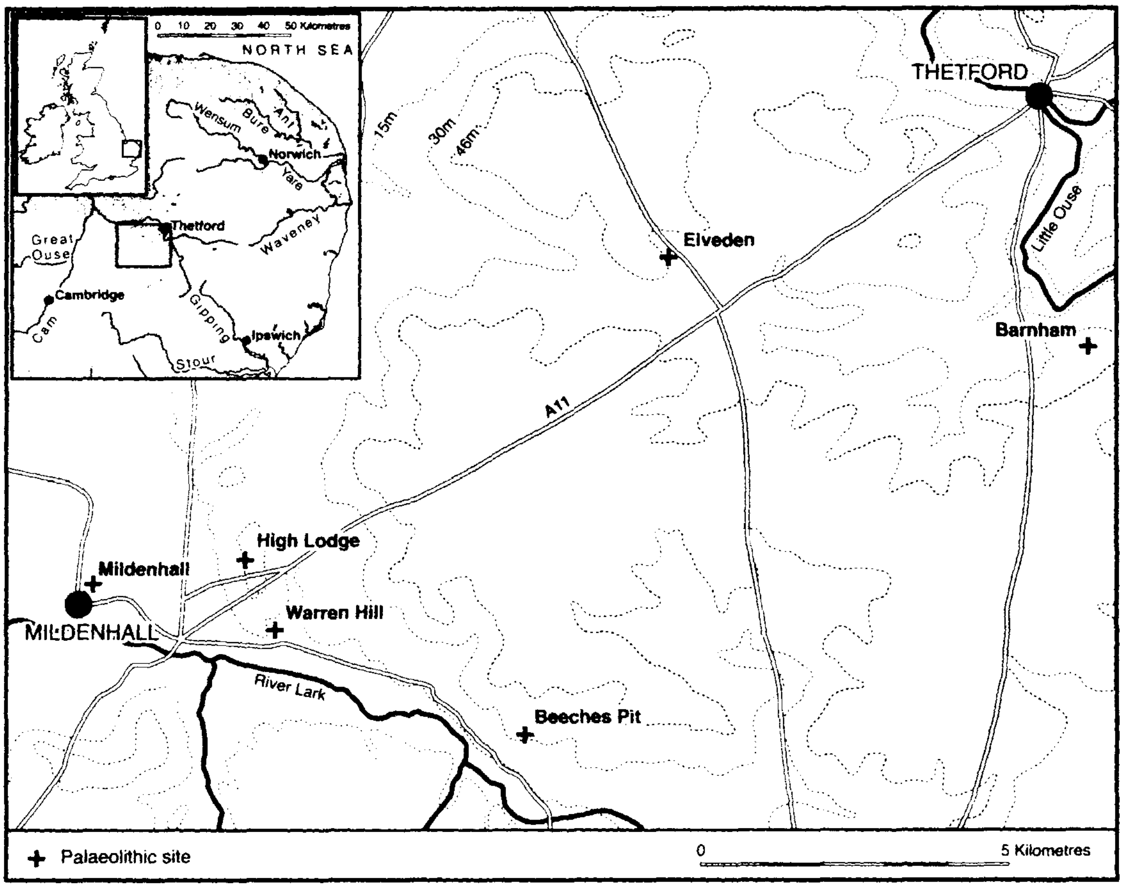


Fig 1.
Location of Elveden

The pit was first opened in the 1890s, primarily for the building of Elveden Hall, which was completed in 1900. Flint artefacts, particularly bifaces, were collected during this period and are now mainly housed at the British Museum (Sturge Collection; Smith 1931), at the Archaeology and Anthropology Museum in Cambridge, and at Elveden Estate Office. The pit continued to be worked until 1918, when it was abandoned. The pit is currently 80 x 40 m and up to 7 m in depth, with a tramway cutting, 50 m in length, descending into the pit from the north-east (Fig. 2).

The first formal excavation at the site was in 1937 (Paterson & Fagg 1940). They excavated three main sections (A, B, and C, see Fig. 3) along the northern edge of the tramway cutting and the south-western side of the pit. The sequence they described is a channel fill with one edge shown by a steep Chalk bank on the north-eastern side, mid-way up the tramway (Fig. 3). The main units identified by Paterson and Fagg (1940) consisted, from bottom to top, of boulder clay overlain by grey-blue loam, brown loamy-sand (with gravel at the base and a coarse gravel at the top), brown stoney [*sic*] loam disturbed by ice-loading at the top, and a decalcified upper boulder clay. The term 'boulder clay' is used in this report only to refer to stratigraphic units identified by Paterson, who recognised lower, middle, and upper boulder clays in the Breckland. It is not appropriate simply to substitute 'till' for boulder clay as some of these deposits are not of glaciogenic origin. The majority of the 600 artefacts recovered by Paterson came from the coarse gravel and from the basal 4 ft (1.3 m) of the overlying brown stoney loam.

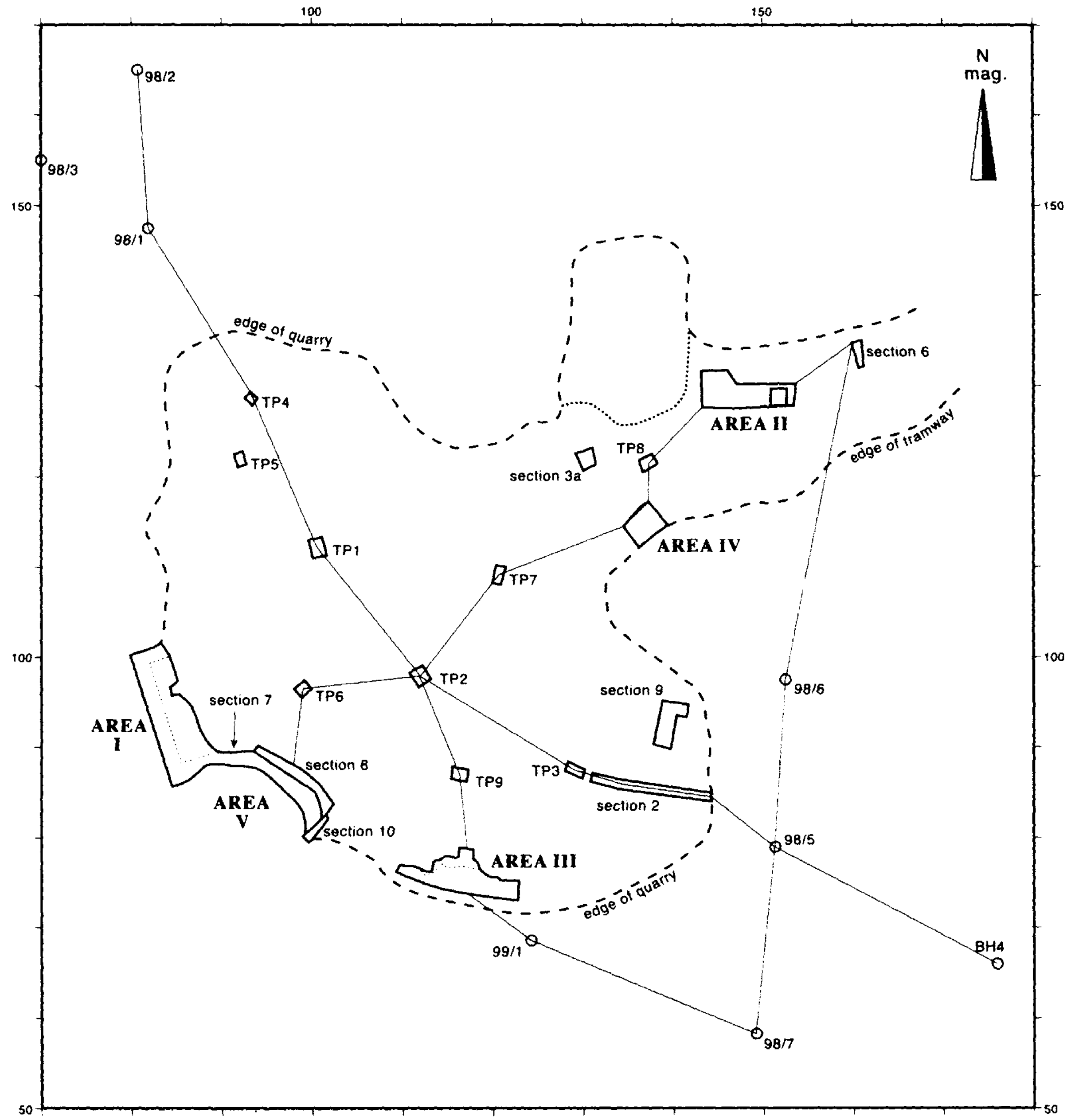


Fig 2.
Plan of brick-pit at Elveden showing excavation areas, sections, test pits, boreholes and location of cross-sections (see Figures 7–9).

The interpretation of Paterson and Fagg was complex and formed part of Paterson's elaborate interpretation of the Breckland sequence (Paterson 1942; McNabb 1998). The basal unit at Elveden (Middle Boulder Clay) was considered to represent a major glaciation, and the overlying sediments were thought to be primarily fluvial in origin with periods of erosion, land surface formation and occasional

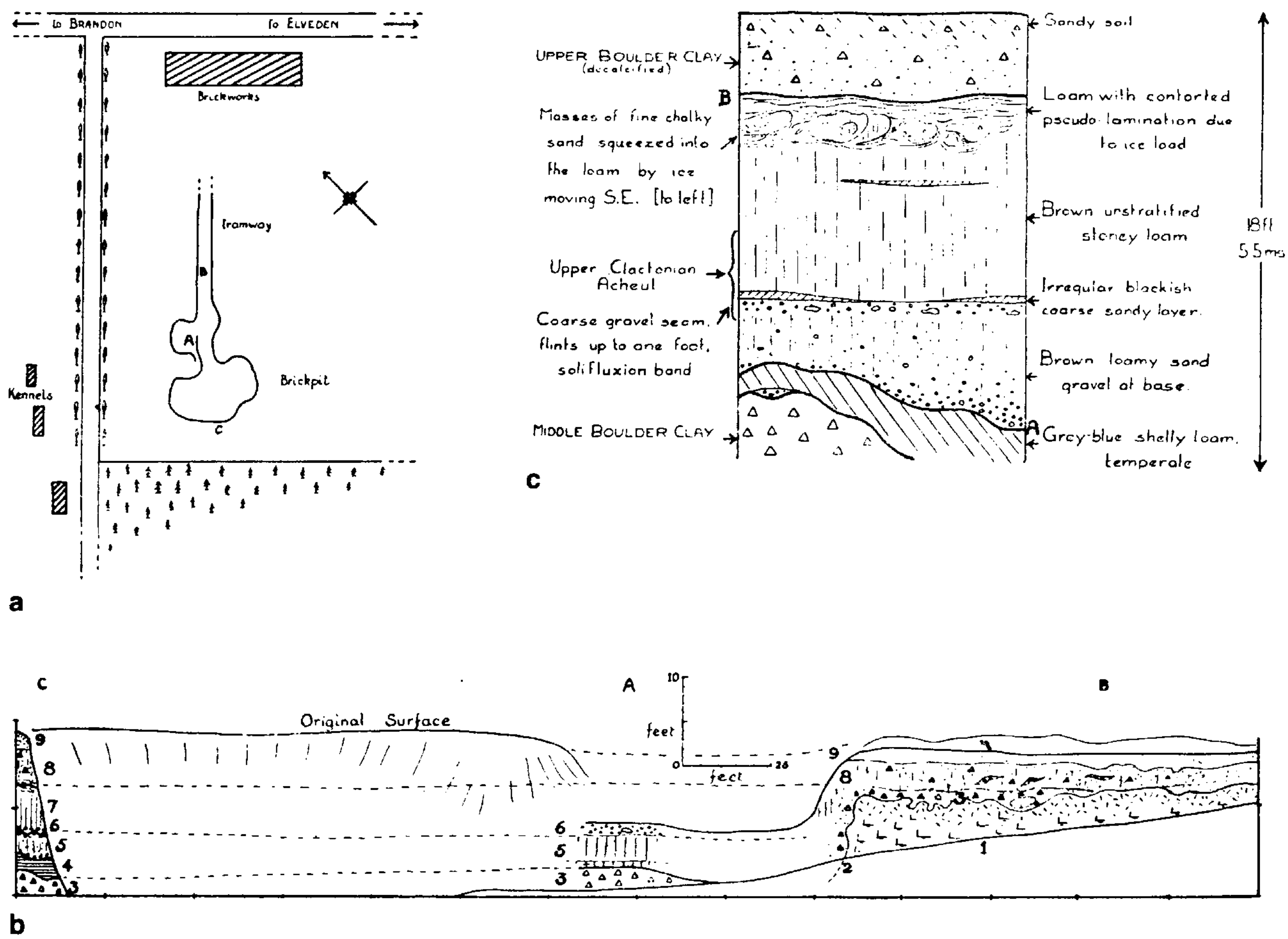


Fig 3.
Plan and sections of pit from Paterson and Fagg (1940). Reproduced by kind permission of the Prehistoric Society.

solifluction. Some of these episodes, such as the deposition of the coarse gravel, were interpreted as major flooding events that occurred not just on a regional, but on a global scale (Paterson 1940–1). The decalcified sediments at the top (Upper Boulder Clay) were regarded as deposits of a further glaciation in the area.

The Lower, Middle, and Upper Boulder Clays recognised in the Brecklands were related by Paterson to the Mindel, Riss, and Würm of Penck and Brückner (1909). Thus at Elveden the archaeology was dated to the Riss–Würm interglacial. In contrast, the deposits at the nearby site of East Farm, Barnham, were sandwiched by the Lower and Middle Boulder Clays and dated to the earlier Mindel–Riss interglacial. Most workers now only recognise one till in the area, the Lowestoft Till (Perrin *et al.* 1979), which occurs at the base of the sequence at both Elveden and Barnham.

Further work was undertaken in 1967 by Gale Sieveking and Charles Turner who cut three sections on the south-western edge of the pit. Pollen analysis was also undertaken on calcareous and organic sediments taken from cores in the centre of the pit (Turner 1973). These sediments, located below the floor of the pit had not been identified by Paterson and Fagg, although the feather-edge of them was seen in their Section C, which they described as grey-blue shelly loam. The palynology suggested that the sediments relate to the first part of an interglacial, which Sieveking and Turner assigned to the Hoxnian. Over a hundred artefacts were also recovered from the sections at the edge of the pit (Table 1). The artefacts from the work both in 1937 and 1967 come from the same series of units as the artefacts in the current excavations and display the same technological features. Equally all the sediments seen in previous excavations have been identified and examined in the recent work at the site.

THE 1995–9 EXCAVATION

The current project was initiated in 1995 following the completion of excavations at the nearby site of Barnham in 1994 (Ashton *et al.* 1998). The main aims of the project were:

1. to re-examine the geological and environmental context for the archaeology;
2. to study the intra-site variation in archaeological signatures; and
3. to relate the geological sequence at Elveden to that at Barnham.

The site was excavated for 18 weeks over five seasons from 1995 to 1999. Five main archaeological areas were examined, of which two (I and III) provided the main lithic assemblages. As part of the geological and environmental work ten sections were cut, most by JCB. In addition, nine test pits were dug and a series of boreholes were completed in order to investigate the geometry of the deposits within and around the brick-pit.

Sections cut by hand in 1995 confirmed previous observations on the location of the archaeological horizons at the site. The main archaeological areas were opened in subsequent seasons, with the upper sterile units removed by JCB. More detailed descriptions of the work are given in Ashton and Lewis (1996; 1997; 1998; 1999; 2000).

Area I was located behind Section 1 and a 15 x 5 m platform was cut by JCB (Figs 2 & 4). Within this, a 12 x 4 m area was selected, leaving a step on three sides, and excavated by hand through 1 metre of 'brickearth' down to and into the coarse gravel beneath (Fig. 5). Area II was a 10 x 3 m area, located behind Sections 4 and 5 (Fig. 6), midway up the tramway cutting. Here, the overlying sediments were largely disturbed and artefacts were excavated from just above and within the coarse gravel at the base. Area III was initially opened as a section, but expanded into an archaeological area on the discovery of *in situ* flint artefacts (Figs 13 & 14). The total area opened was 14 x 5 m at the widest point. Approximately 1.2 m of 'brickearth' containing a sparse distribution of artefacts was excavated by hand down to a thin horizon of black clay, which contained *in situ* archaeology. Area IV was opened behind Section 3 towards the bottom of the tramway. Artefacts were excavated from a 1.5 x 2.5 m area from just above and within the coarse gravel. Area V was excavated to help relate Areas I and III. Initially it was opened as Section 8, and then expanded into a 11 x 1 m strip as part of a *Time Team* programme for television's Channel 4 in 1999. Artefacts were recovered from the black clay, and from the underlying gravel layer.

The test pits and sections were opened partly to contribute to the understanding of the stratigraphy at the site, but also to provide access to the calcareous grey silt/clay for environmental sampling. Samples were taken from Test Pits (TP) 1, 2 and 3 and Sections 2 and 9, and were processed for vertebrates, molluscs and ostracods. In addition samples were taken from a borehole located in TP 1 for pollen analysis.

GEOLOGICAL STUDIES

STRATIGRAPHY OF THE SITE

(SL)

The stratigraphical investigations have established the detailed succession within the brick-pit and enabled the archaeological assemblages to be placed within a clear lithostratigraphical and palaeoenvironmental framework. The lithostratigraphic classification of the Elveden succession is shown in Table 2. Formal lithostratigraphic nomenclature follows Lewis (1999).

The Chalk surface

Paterson and Fagg (1940) recorded Chalk at the base of the succession along the length of the tramway cutting (their section B). The Chalk has a steep edge at its western limit, where it is overlain by till. The Chalk was re-exposed during the current investigations in Section 6 and in Area II (Fig. 4). The steep edge seen by Paterson and Fagg is exposed at the western end of the Area II section, where it is overlain by chalky diamicton (a poorly sorted mixture of gravel, sand, silt, and clay) (bed 1). Here the Chalk surface is at around 41–2 m OD. The Chalk surface was also proved in the base of BH 98/7, to the south of the

TABLE 1: SUMMARY OF ARTEFACTS EXCAVATED BY SIEVEKING AND TURNER IN 1967.

Context names	*red sand and flint*	*grey clay with flint pebbles*	*grey-green sand and flint*	*occupation level*	*orange grey sand and flint*	*not in situ*
Cutting	1	1	1	1	2	
Equivalent bed no.	5	5	5	3	3	
Flakes	18	4	17	7	15	36
Cores	1	0	0	1	0	5
Scrapers	0	0	1	0	0	1

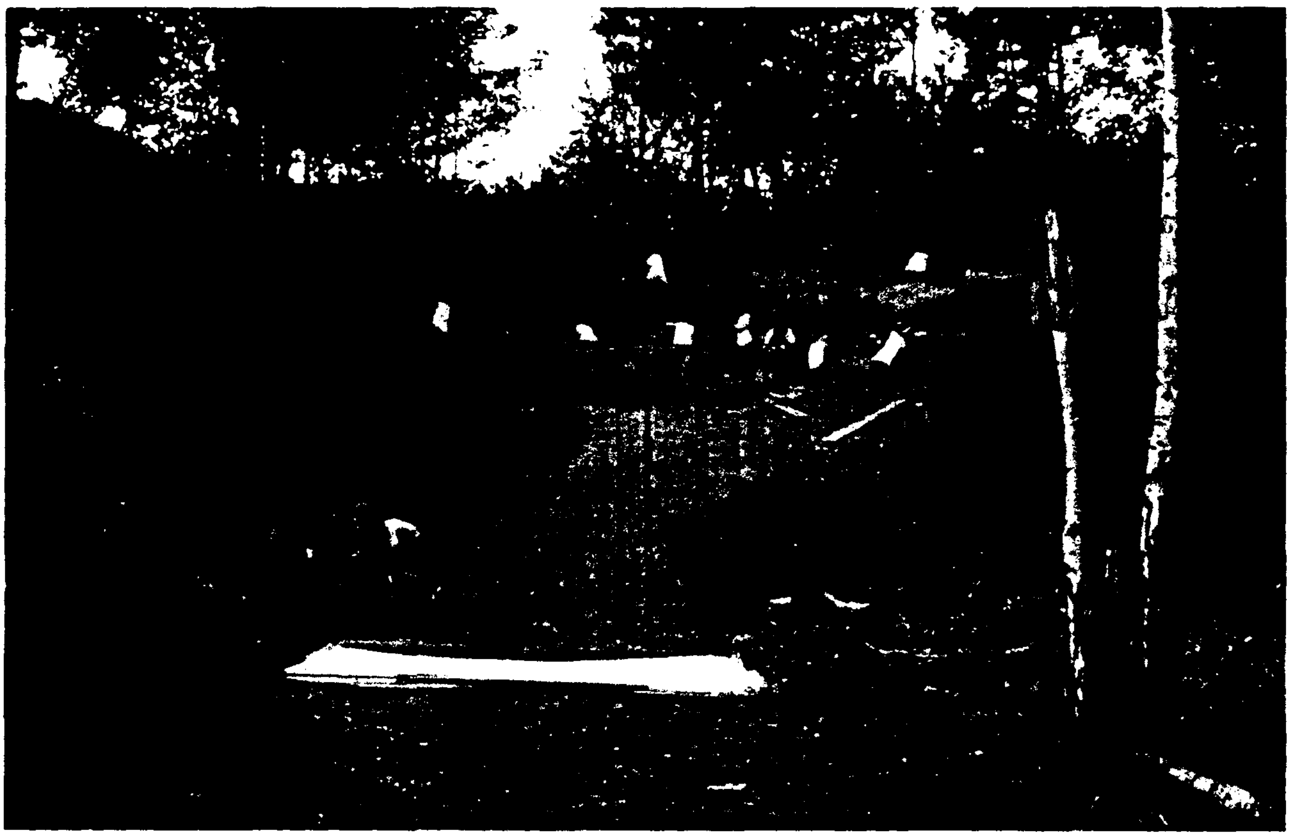


Fig 4.
General view of the brickpit and Area I from the north-east. The chalky diamicton (bed 1) can be seen in Section 7 at the base of the brick-pit on the left-hand side.

brick-pit (Fig. 2) at an elevation of 41.6 m OD (Fig. 8). In the centre of the brick-pit, augering in the base of TP1 revealed Pleistocene sediments down to c. 30 m OD, without locating the Chalk. Therefore, the Pleistocene sediments occupy a depression in the Chalk bedrock, and the Chalk surface slopes at a steep angle from the east and north-east towards the centre of the pit. As Chalk was not proved to the west or north of the pit the geometry of this feature can not be established in greater detail.

Paterson and Fagg (1940, 5) suggest that the vertical Chalk edge is the margin of a river channel, which was cut into the bedrock and subsequently filled with 'boulder clay' and overlying deposits. Investigation of Area II during the current excavations indicates that this area is probably affected by Chalk

Fig 5.
Area I gravel layer (bed 3) from the north.

solution. This interpretation is based on the depths of the overlying sediments (bed 5) at the weathered end of the section, the presence of stringers of pebbles within bed 5 which slope down to the west, the lower elevation of the artefact horizon, compared with Area IV, less than 20 m away, and finally the evidence of decalcification of the Chalk and overlying chalky diamicton at the eastern edge of the section. The Chalk edge is therefore the result of solution, rather than fluvial erosion, although solution could have modified an existing cliff edge.

Bed 1: chalky diamicton

The chalky diamicton forms the basal Pleistocene stratum across the entire site. It was recognised in sections, test pits, and in boreholes. Its upper surface forms a depression; the deepest point coincides approximately with the centre of the brick-pit (Fig. 7). The depression is approximately 50 m west–east and around 150 m north–south; it is therefore elongated in a north–south direction. The feature is around 10 m deep at the deepest point, with the chalky diamicton surface at 30 m OD in TP1 (BH95/2). The steeply dipping surface of the chalky diamicton was exposed in section 7 (Figs 4 & 9); in places the slope of this contact is approximately 0.5 m/m.

The chalky diamicton consists of a poorly sorted mixture of mainly chalk and flint clasts in a silt/clay matrix. The matrix colour is dark yellowish brown (10YR 4/6) to light olive brown (2.5Y 5/4) in colour. In a number of sections the upper part of this bed is decalcified, changing the matrix to a predominantly dark yellowish brown (10YR 4/6) colour. The clasts consist mainly of chalk (>80%), with flint forming the other major constituent (*c.* 10%) (Table 3). Very minor quantities of quartzite and quartz (1–2%) are also present. Also among the minor lithologies are *Rhaxella* chert, limestone, soft sandstone, Jurassic shell fragments, and igneous clasts, all of which are typical of glacial deposits in the area (Bridgland & Lewis 1991; Bridgland *et al.* 1995). The clast fabric, based on two samples taken from

TABLE 2: LITHOSTRATIGRAPHIC CLASSIFICATION OF THE ELVEDEN SUCCESSION

bed		*Member*	*Formation*	*UK Stage*	*MIS*
6,	coversands			Devensian	2
5,	brown silt and clay				
4,	black clay		Elveden	Hoxian	11
3,	gravel				
2,	grey silt and clay				
1,	chalky diamiction	Lowestoft Till	Lowestoft	Anglian	12

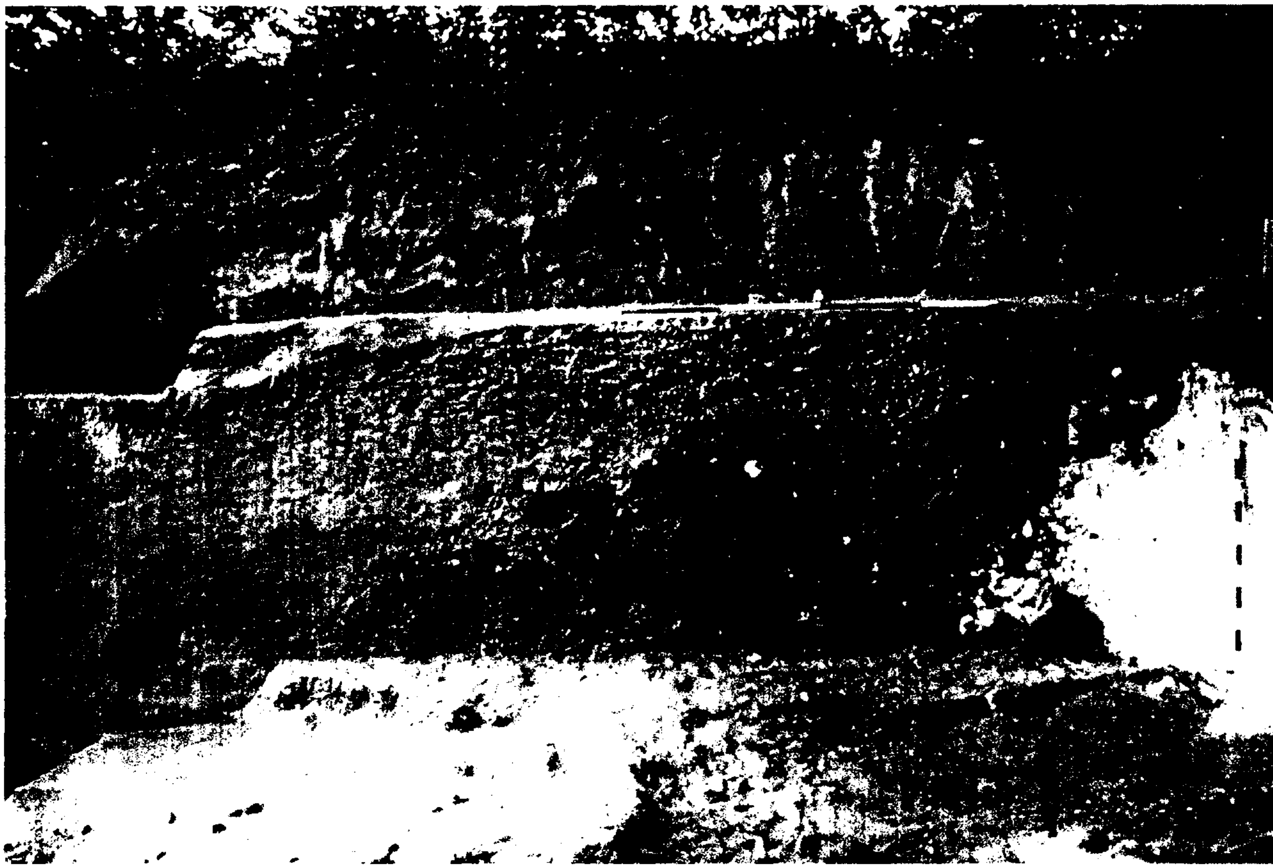


Fig 6.
Section in Area II showing edge of basin, infilled with 'brickearth' (bed 5), with Chalk on the right-hand side.

section 7, indicates a statistically significant west–east orientation (Fig. 10).

The chalky diamicton is interpreted as a glaciogenic unit, part of the regionally extensive Lowestoft Till Member. The west–east clast orientation suggests an ice flow direction from the west and is consistent with directional data from East Farm, Barnham (Lewis 1998) and High Lodge (Lewis 1992) and is also consistent with the regional reconstruction of ice flow by West and Donner (1956) and Rose (1992).

Bed 2: grey silt/clay

This deposit overlies the chalky diamicton across much of the central part of the pit occupying the deeper parts of the depression in the surface of the diamicton (Fig. 7). It thins out towards the edges of the depression and is not present in some of the sections around the edges of the brick-pit as it has been cut out against the rising surface of the chalky diamicton. This deposit has been substantially removed for brick manufacture, but over 6m remain preserved in the deeper parts of the depression (TP 1 and BH 95/2; Fig. 7).

The colour of this deposit varies from light grey (2.5Y 7/2), through greyish brown (2.5Y 5/2), yellowish brown to olive yellow (2.5Y 6/6), though it has a generally grey appearance in the field. Decalcification and oxidation also affect its upper part causing a change to a yellowish brown (10YR 5/6) to light olive brown (2.5Y 5/6) colour. In the centre of the depression this unit has a significant organic component giving the deposit a dark grey to black colour. The unit is mainly massive, though in places the sediments are laminated; this was visible in Area III and in TPs 3 and 9 (Fig. 12). The laminations

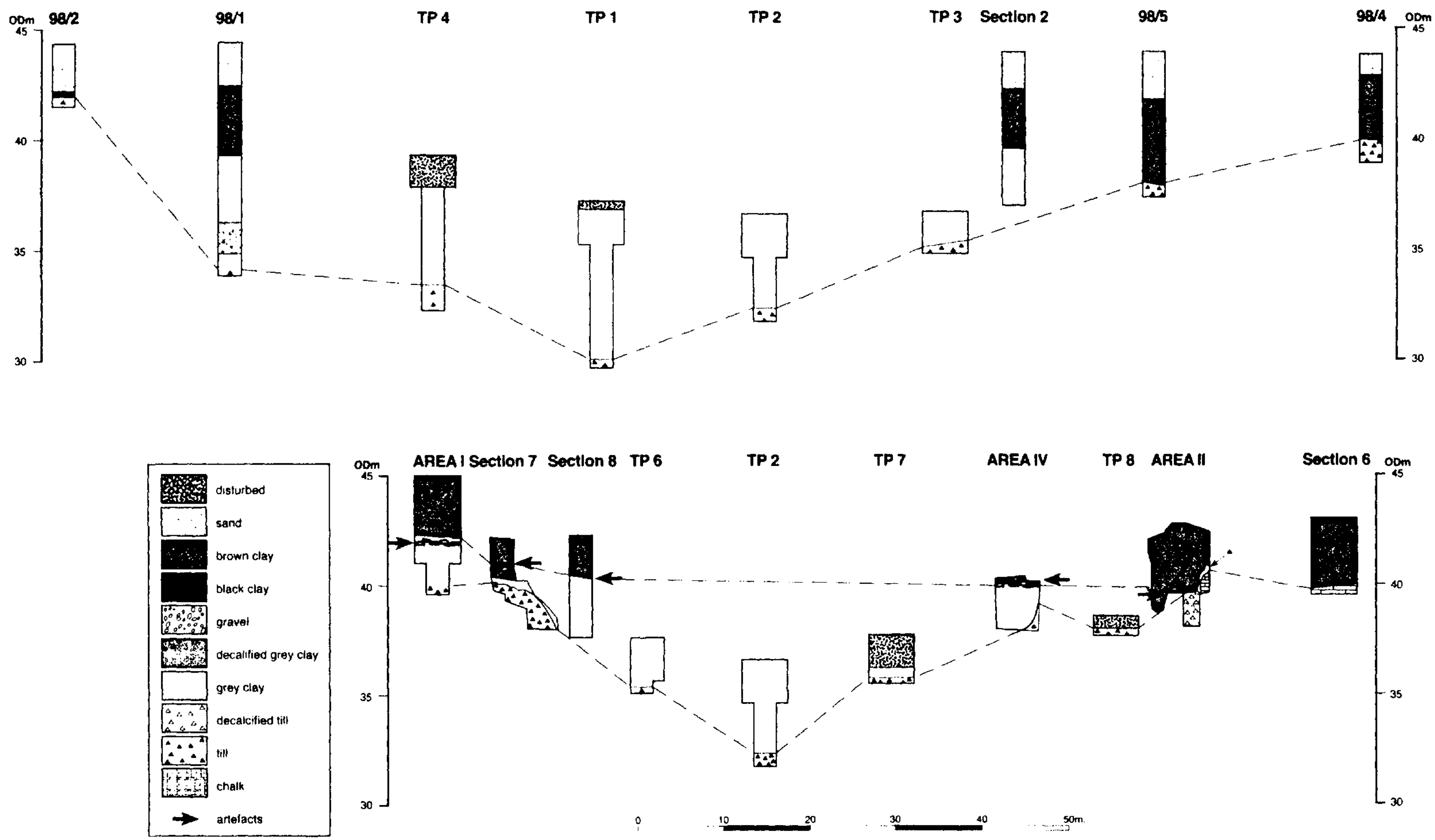


Fig 7.
Cross sections: top, north-west to south-east; bottom, south-west to north-east across the brick-pit (see Fig. 2).

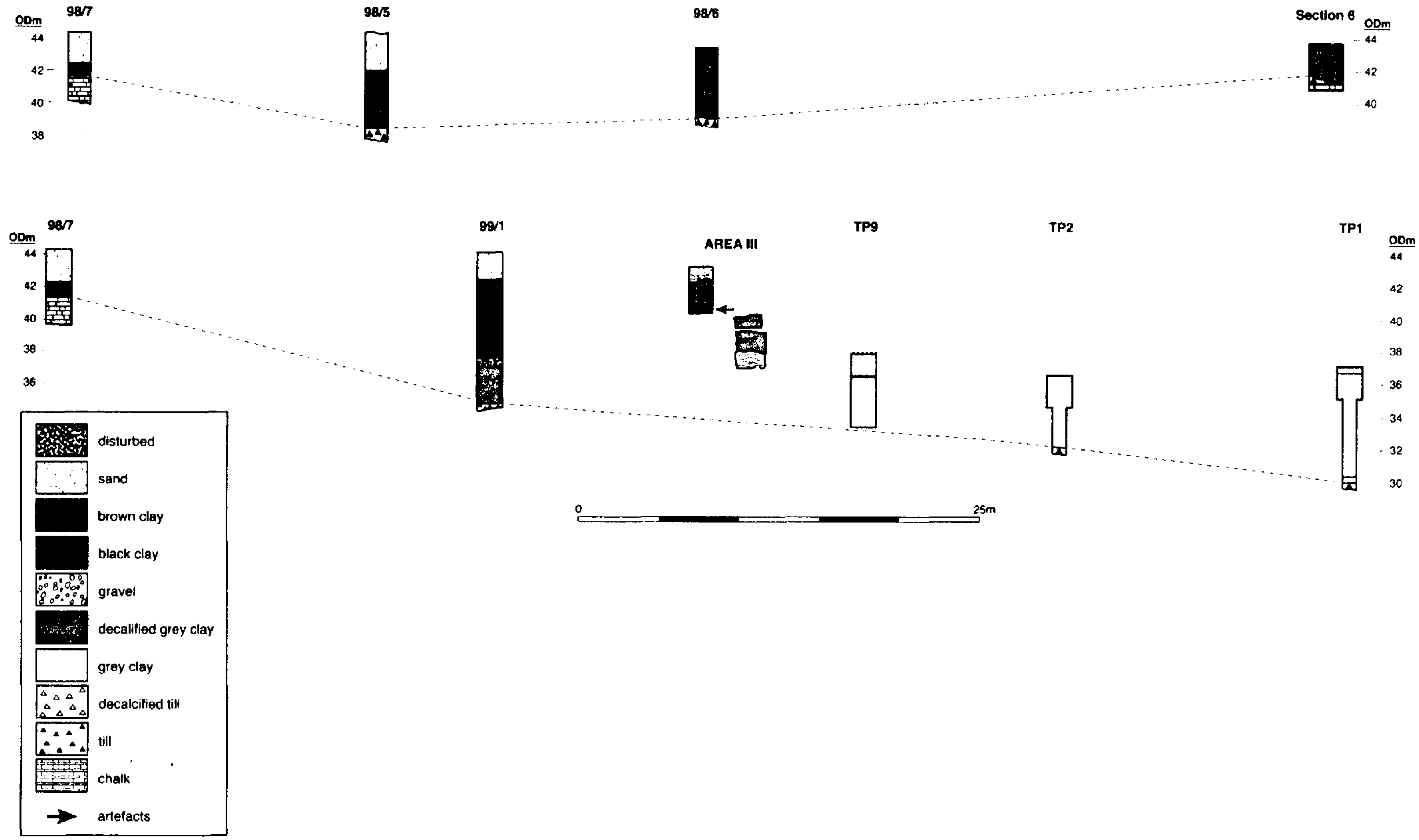


Fig 8.
Cross sections: top. south to north to the east of the brick-pit; bottom. from the south-east to the middle of the brick-pit (see Fig. 2).

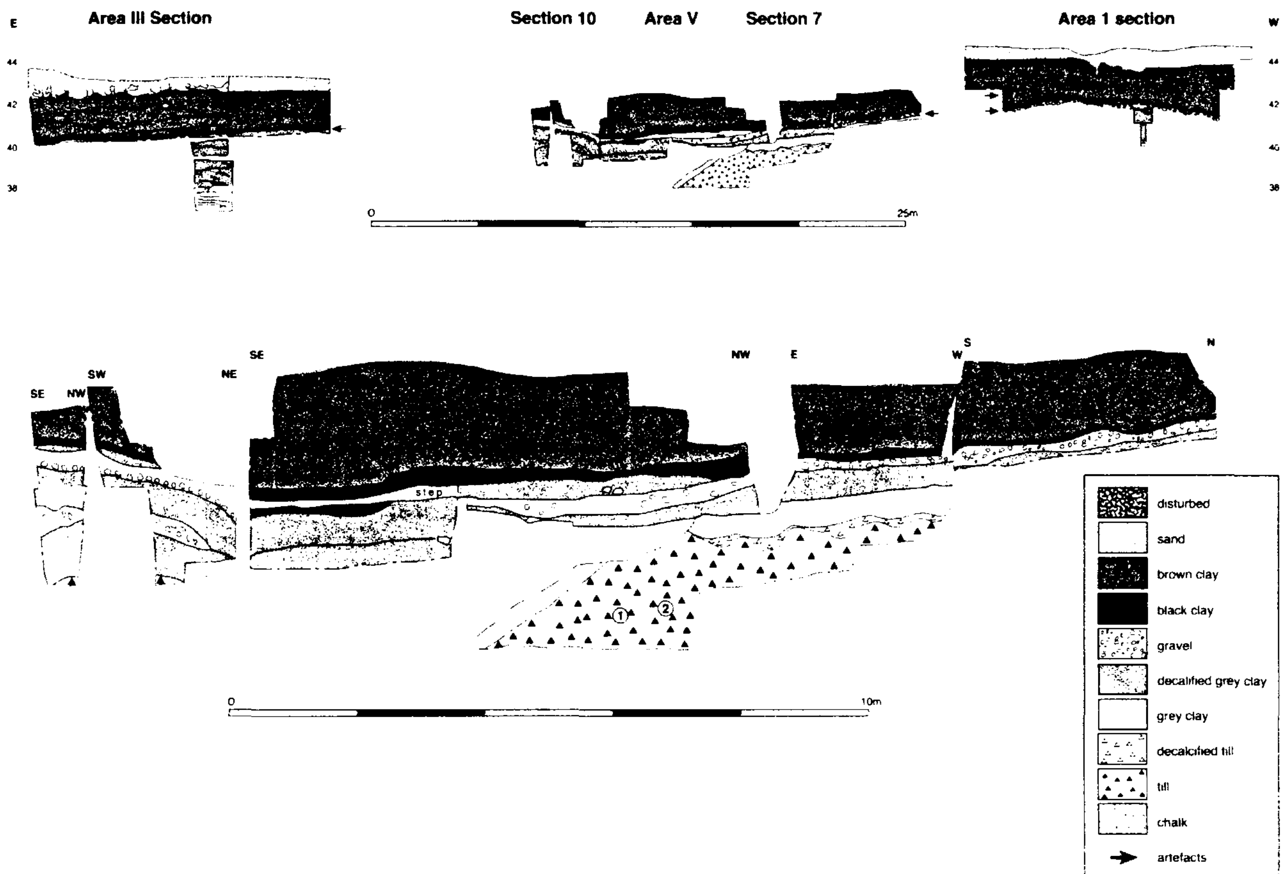


Fig 9.
Top. Cross section along the southern and south-western edge of the brick-pit (see Fig. 2); bottom. detail of Section 10, Area V and Section 7. Till fabric samples 1 and 2 are shown in Fig. 10.

appear to be better developed in the lower part of the unit. The sediment is stoneless, with a predominantly silt/clay texture.

Bed 2 was deposited under low energy conditions in a still to slow-flowing water body. The presence of organic sediments and lamination may indicate lacustrine conditions for at least part of the deposition of this unit. This unit represents the infilling of the depression in the chalky diamicton.

Bed 3: gravel

The gravel of bed 3 is only preserved around the margins of the depression. It forms a thin spread of cobbles in Areas I, V, and III on the south-west side of the brick-pit and is also present in Areas II and IV on the north-east side of the pit (Fig. 5). The elevation of the gravel is 40–42m OD, it slopes into the centre of the depression (as seen in Area III and Section 10, Fig. 9) and it is also affected by solution of the underlying Chalk in Area II (Fig. 7). The gravel is best developed in Section 7 and Area I, where it reaches a thickness of 0.3 m (Figs 5 & 11). Here it consists of poorly sorted deposits of flint gravel in a clayey matrix and no structures are visible. Where the gravel is thinner it occurs as a layer of flint gravel and cobbles, both forming a dense spread, as in Areas IV and V, or a more dispersed distribution of gravel, as in Area III. The colour of the matrix of the gravel is dark brown (7.5YR 3/2) to brownish yellow (10YR 6/6). The clast lithology of the gravel is dominated by flint (85–90%), with minor quantities of quartz, quartzite, and chert (Table 3). The deposit is non-calcareous throughout. In Area II the gravel is associated with

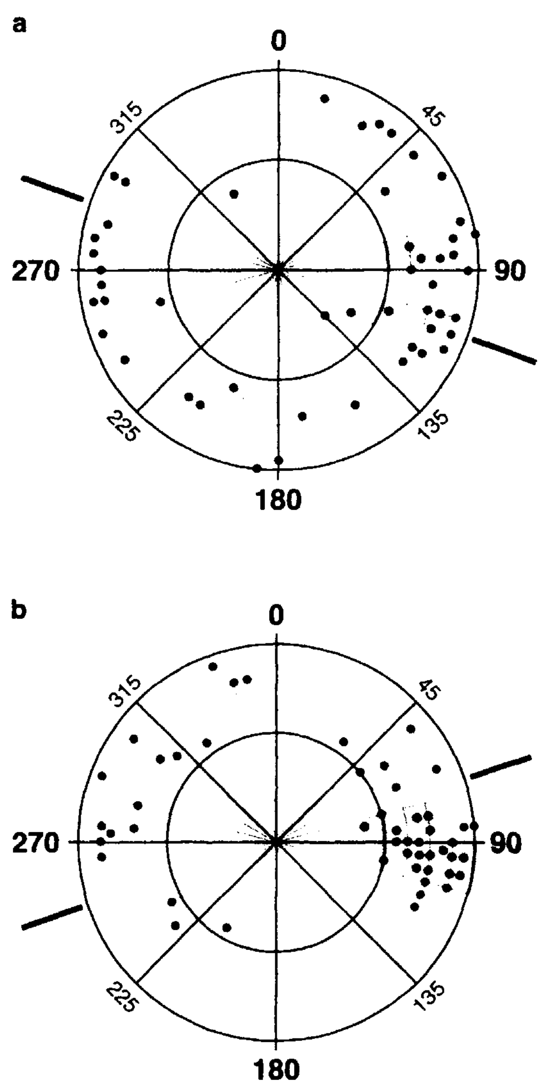


Fig 10.
Fabric analyses from bed 1, Section 7.

prominent steep-sided hollows, some of which display under-cut edges. The hollows are roughly circular, 30–50 cm across and reach over 30 cm in depth.

The gravel is interpreted as a lag-deposit, representing the coarse material unable to be transported by water flow across the surface. Higher energy flows clearly occurred at times, as the hollows in Area II strongly resemble scour features formed by turbulent water flow. The gravels therefore represent a surface that was periodically flooded by flowing water, but with insufficient energy to move the gravel fraction. Flint artefacts were found in the gravel in all the areas.

Bed 4: black clay

In common with bed 3, the black clay is now only preserved around the margins of the depression and it forms a thin (10–30 cm) layer either directly overlying the cobbles (Area III) or separated from them by a few centimetres of brown clay (Fig. 12). The black colour (10YR 2/1) is best developed in Area III (Fig. 14), though the unit can be seen in Areas I and V and in Section 7 as a darker coloured sediment (Fig. 9). It therefore forms a laterally continuous layer, coinciding with the distribution of bed 3 around the south-western periphery of the depression. This bed could not be traced across the centre of the depression, though its occurrence in Section 8 (Fig. 9), slightly further towards the centre of the depression, may suggest that it once formed a more extensive layer, possibly extending right across the infilled depression. The origin of this unit is discussed more fully in the micromorphology section below. Artefacts, often in fresh condition, were found on and within this unit, particularly in Area III (Figs 13 & 14).

Bed 5: brown silt and clay ('brickearth')

Overlying the black clay in Areas I, III, and V is a predominantly yellowish brown (10YR 5/8) to dark yellowish brown (10YR 4/6) fine grained deposit, with occasional sandy laminations and with sporadic flints (Fig. 13). This deposit occurs elsewhere within the brick-pit in the upper part of the sections and is also present outside it, where it was proved in boreholes (Figs 7 & 8). Its distribution is not therefore confined to the depression in the chalky diamicton. The sediment is mainly silt and clay and is non-calcareous throughout.

This deposit probably formed by colluvial processes, with deposition of fine-grained sediments resulting from slope-wash down local slopes. The presence of sands may indicate occasional high energy flows. Flint artefacts were found dispersed in the lower 1–1.5 m of this unit in Areas I and III.

Bed 6: coversand (and involutions layer)

The uppermost unit in the succession is a sandy deposit, forming a thin layer on top of the 'brickearth' and beneath the soil layer (Fig. 13). The lower contact

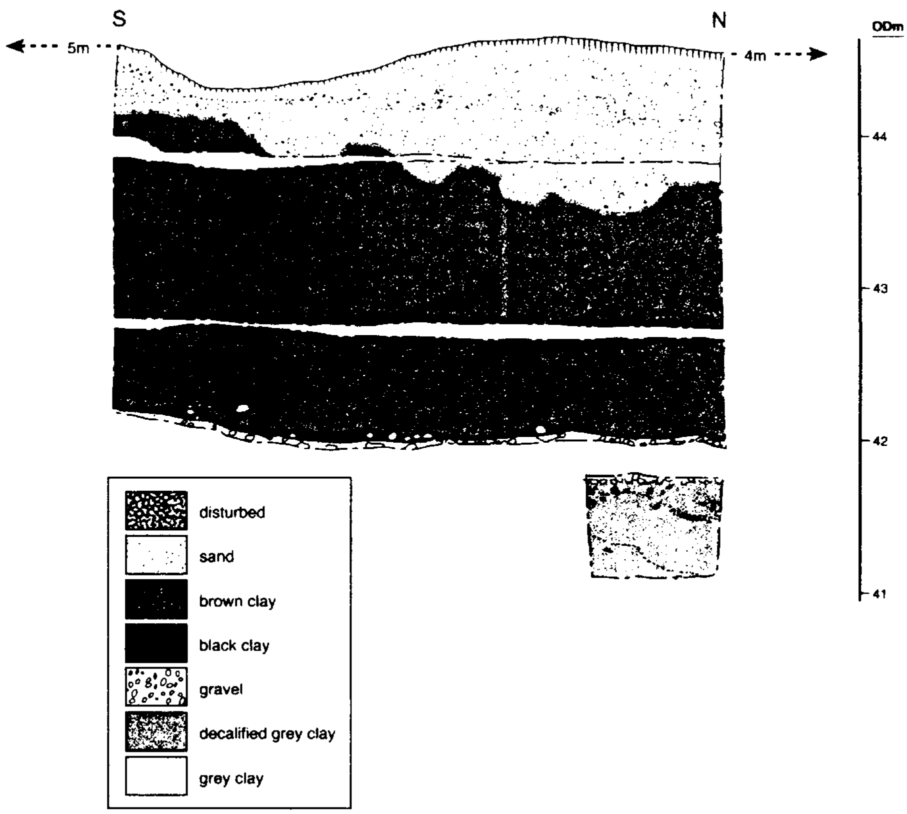


Fig 11.
Area I section. Full section extends 5 m to the south and 4 m to the north.

of this bed shows well-developed involutions in the sections in Areas I, III, and V. These involutions were noted by Paterson and Fagg (1940) and ascribed to a glacial origin. However it is more likely that they represent periglacial involutions. Bed 6 is a coversand deposit, which is windblown sand that formed a sheet across the Breckland, laid down mainly during the last cold stage (Bateman 1995; Clarke *et al.* 2001). The coversands are often associated with periglacial structures (Corbett 1973; Bateman 1995), being

TABLE 3: CLAST LITHOLOGY (8–16 MM FRACTION OF THE GRAVEL BED 3) AND THE CHALKY DIAMICTON (BED 1)

sample number	*qtz*	*qtzte*	*sst*	*glauc sst*	*Carb chert*	*Rhaxella chert*	*flint*	*chalk*	*lst*	*soft sst*	*ironst*	*Jurassic shell*	*ign*	*meta*	*other*	*n*
bed 3: gravel																
96/1	2.4	3.1	0.2	0.0	2.5	0.8	86.7	0.0	0.0	0.7	2.2	0.0	0.4	0.1	0.8	1118
96/2	2.3	2.7	0.6	0.0	1.9	0.2	90.9	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.6	525
97/1	3.8	6.0	0.3	0.1	1.7	0.3	85.3	0.0	0.0	0.0	1.8	0.0	0.2	0.0	0.7	1085
97/2	3.2	3.8	0.5	0.0	1.3	0.3	87.2	0.0	0.0	0.0	1.4	0.0	0.6	0.4	1.3	783
bed 1: chalky diamicton																
96/3	0.8	0.8	0.9	0.0	1.4	0.0	10.3	82.4	1.9	0.0	1.0	0.5	0.0	0.0	0.0	778
96/4	0.3	0.4	0.9	0.1	0.9	0.1	9.2	83.8	2.2	0.3	0.3	1.2	0.3	0.0	0.0	760

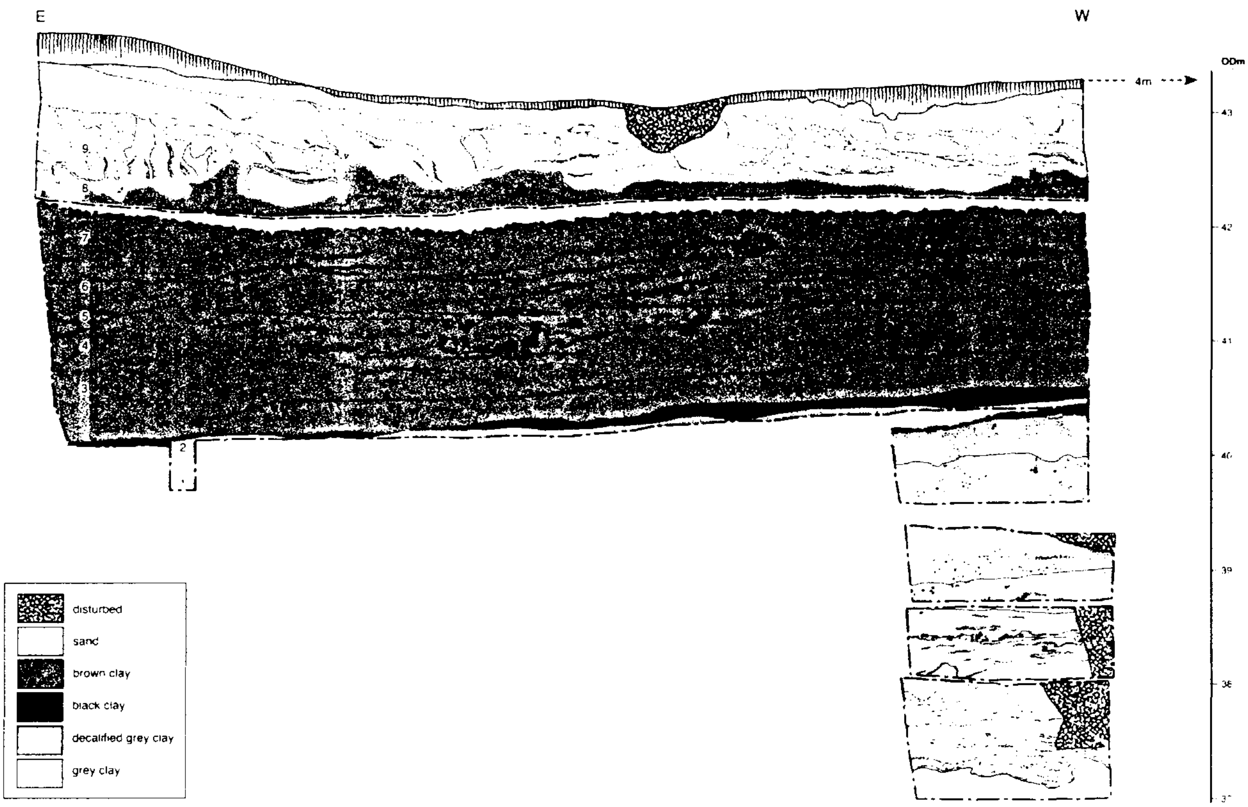


Fig 12.
Area III section showing position of micromorphology samples 1–9. Full section extends 4 m to the west.

Fig 13.
Area III, showing excavation prior to the removal of the black clay (bed 4). 'Brickearth' (bed 5) is shown in the section, overlain by coversand and involution layer (bed 6).

Fig 14.
Area III showing excavation of the black clay with *in situ* artefact assemblage. The black clay can be seen in the section, immediately above the excavation horizon.

preserved within the involutions. This is the situation at Elveden.

MICROMORPHOLOGY
(RAK)

Nine undisturbed blocks were collected within Kubiena tins (7 x 5 x 4 cm) at 30–40 cm intervals through the uppermost part of bed 2 (grey silt/clay), bed 4 (black clay), bed 5 ('brickearth') and bed 6 (coversand and involutions layer) from Area III. A further four blocks from bed 2 and one more from bed 4 were taken from the overlapping Section 8. Each block was air-dried, impregnated with polyester resin and made into thin sections according to standard procedures (Lee & Kemp 1992). Analysis of these 14 thin sections at 10–400 x magnification under a polarising microscope indicates that the four lithological units reflect a complex pedosedimentary history similar to that reported for the Area I sequence at Barnham (Ashton *et al.* 1994; Kemp 1998).

The black clay (bed 4) contains numerous degraded root fragments and embedded aggregates interpreted as remnants of a granular soil structure. Together with the apparent organic staining of the fine material in the groundmass, the evidence points to this bed being a diagenetically-altered remnant of an A horizon of a soil. The B and C horizons of the soil formed in the upper part of bed 2 and are characterised by many ferrimanganiferous nodules, segregations, coatings, and root pseudomorphs indicative of redoximorphic pedogenic processes under anaerobic conditions. Overall, the upper part of bed 2 and bed 4 represent a poorly-drained soil formed at a land surface, not necessarily of any great duration, subject to periodic flooding and possibly minor sediment accretion and reworking.

The 'brickearth' (bed 5) above the black clay is mottled with common ferrimanganiferous segregations and coatings. Other pedological features include illuvial clay coatings around channels, formed by the accumulation of clay-size particles moved down in suspension from overlying surface soil horizons. It seems likely that this unit has had a complex pedosedimentary history with phases of sedimentation interspersed with periods of relative stability when pedogenic processes were active. The absence of clearly-defined A horizons buried within the 'brickearth' may be due to erosion or, alternatively, diagenetic oxidation of organic matter and minimal thicknesses of covering sediments or low aggradation rates so that A were transformed into B horizons of subsequent soils as the surface accreted. The occurrence in the same thin sections of ferrimanganiferous concentration features either superimposed on (ie, post-dating), or coated by (ie, pre-dating), illuvial clay features indicate a complex and perhaps varying pedogenic environment with both redox and translocation processes active throughout the development of the 'brickearth' unit.

A few clay coatings extend down from the 'brickearth' into the poorly-drained soil of the black clay and grey silt/clay (beds 4 and 2), in all cases post-dating the ferrimanganiferous concentration features. This consistent microstratigraphic relationship is critical as it shows that these illuvial clay features are not contemporaneous with the development of the poorly-drained soil and instead were superimposed or welded onto this soil through later translocation processes initiated within the covering 'brickearth' (bed 5).

A second key microstratigraphic ordering of features occurs higher up in the section within bed 6 where coarse-textured coversand has been cryogenically mixed with the 'brickearth'. Here, the presence of significant quantities of fragmented and deformed clay coatings within the 'brickearth' components indicate that clay illuviation occurred prior to periglacial disruption. Undisturbed clay coatings around channels and sand grains in the same thin sections, however, date from a subsequent (probably Holocene) phase of illuviation.

In conclusion, the complete sequence through beds 2, 4, 5, and 6 at Elveden should be considered as a soil complex consisting of a series of overlapping or welded sola. Four distinct pedosedimentary stages are responsible for its formation:

1. deposition of fluvial sediments, stabilisation of the land surface and development of a poorly drained soil (beds 2 and 4);
2. deposition of the 'brickearth' (bed 5) with periodic surface stabilisation and soil formation leading to superimposition of illuvial clay features on the underlying poorly drained soil and welding of sola within the 'brickearth';
3. deposition of coversand and cryoturbation (bed 6);
4. Holocene soil development within (and possibly beneath) the cryoturbated horizons.

SECONDARY PRECIPITATES (IC)

Secondary carbonates occur in the upper part of the unit of grey silt/clay (bed 2) from Section 9. These take the form of rounded nodules of siderite (Fe CO_3) and elongate calcite tubules. These precipitates were examined from sieved residues and consequently their distribution and orientation was not observed *in situ*. The siderite nodules have a pustulose form, are slightly elongated, and reach up to 1.5 cm along their longest axis. The calcite tubules occurred in two major morphological types: 1) small (< 1 mm in diameter, < 1.5 cm in length) carbonate coatings around tubular voids; and 2) fragments of carbonate coatings from around larger tubular voids (fragments indicate 1–1.5 cm in diameter). The small tubular features comprise a central tubular void from which numerous smaller tubular voids branch. Under SEM these features exhibit evidence for biological calcification in the form of needle fibre calcite. Stable isotopic analysis of both large and small tubular carbonates indicate $\delta^{18}O$ values of between –4.09 and –4.65 ‰ (12 samples) and $\delta^{13}C$ values of between –5.06 and –8.86 ‰ (12 samples). Stable isotopic values are given relative to an internal national standard: VPDB. Noticeably, whilst all the samples analysed have consistent $\delta^{18}O$ values there is a significant difference between the $\delta^{13}C$ of the small tubular carbonates (between –5.06 and –6.62 ‰) and the large fragmented carbonates (between –8.28 and –8.86 ‰).

The morphology and micromorphology of the small and large calcite lined tubules are characteristic of rhizoliths or rhizocretions (Klappa 1980). These terrestrial carbonates reflect the precipitation of calcite around the surface of roots as a result of 1) changes in the near root geochemistry because of respiration or photosynthesis and 2) microbial processes on the root surface (Klappa 1980; Wright & Tucker 1991). If the host sediments for these rhizoliths are interpreted as freshwater sediments then these calcite forms reflect a drying out of the environment and the formation of fully terrestrial conditions either as a result of the initiation of a drier climate (extrinsic climatic conditions) or because of sediment infilling/lateral migration of the channel system (intrinsic controls). Rhizoliths, along with other calcrete types, are typically used to indicate the existence of a dry climate, either a semi-arid climate or a humid climate with pronounced dry months (see discussion in Wright & Tucker 1991 and Strong *et al.* 1992). There are, however, exceptions to this (Strong *et al.* 1992) and it is possible that the carbonate rich host sediment may have helped to induce precipitation. As rhizoliths may form over relatively short periods of time, ie, the lifetime of the root, these features may not represent a long-lived period of land surface stability and soil development but could reflect a relatively short-lived land surface (Candy 2002).

Significantly, the $\delta\ ^{18}O$ values of these rhizoliths are heavier than those of carbonates forming from surface waters in this region at the present day (Andrews *et al.* 1993). The 'heavy' isotopic signature of the Elveden carbonates could reflect either climates warmer than the present, during which the isotopic composition of precipitation would have been heavier than that of the present day, or a dry aspect to the climate, resulting in soil moisture evaporation prior to calcite precipitation and, therefore, a heavier isotopic signature. The difference in the $\delta^{13}C$ values of the small and large rhizolith forms is suggested to reflect the position within the soil profile at which the rhizoliths precipitate. The large rhizoliths, with $\delta^{13}C$ values of between –8.28 and –8.86 ‰, are typical of pedogenic carbonates formed under a C3 vegetation (Cerling *et al.* 1989) this would be characteristic of the British flora throughout the Quaternary period. The much lighter $\delta^{13}C$ values of the small rhizoliths is most readily explained by them forming nearer the land surface and consequently recording a mixture of soil produced CO_2 and atmospheric CO_2. The consistent $\delta\ ^{18}O$ values indicate, however, that the carbonate were forming at similar temperatures and from similar water sources.

The origin of the siderite nodules is ambiguous as they could reflect either diagenesis of the fluvial sediments in association with near surface groundwaters, suggesting that they formed prior to the onset of fully terrestrial conditions, or pedogenic activity associated with soil horizons further up in the sequence, which would suggest that they formed after the abandonment of the fluvial system. On current evidence it is not possible to suggest which of these proposed origins is correct.

BIOLOGICAL, PALAEO ENVIRONMENTAL AND DATING EVIDENCE

The biological remains were found exclusively in the grey silt/clay (bed 2), the sediment that infills the basin and, underlies the archaeology at the site. However, within bed 2, preservation was very uneven, so that different biological remains have contributed to different parts of the sequence within that bed. A further difficulty was that test pits in the centre of the pit could not be directly related to sections on its edge. Two main areas contributed to the sampling. The first was the borehole at the base of TP1, which revealed the lower part of the sequence and contributed to the pollen from the site. The second area was the sequence revealed by Section 9, and Section 2 (Fig. 15). It was from this part of the sequence that most of the faunal remains were recovered. The botanical remains have therefore contributed to an understanding of the earlier part of the infilling of the basin, while the faunal remains have provided information about a later phase, immediately prior to the evidence of humans at the site.

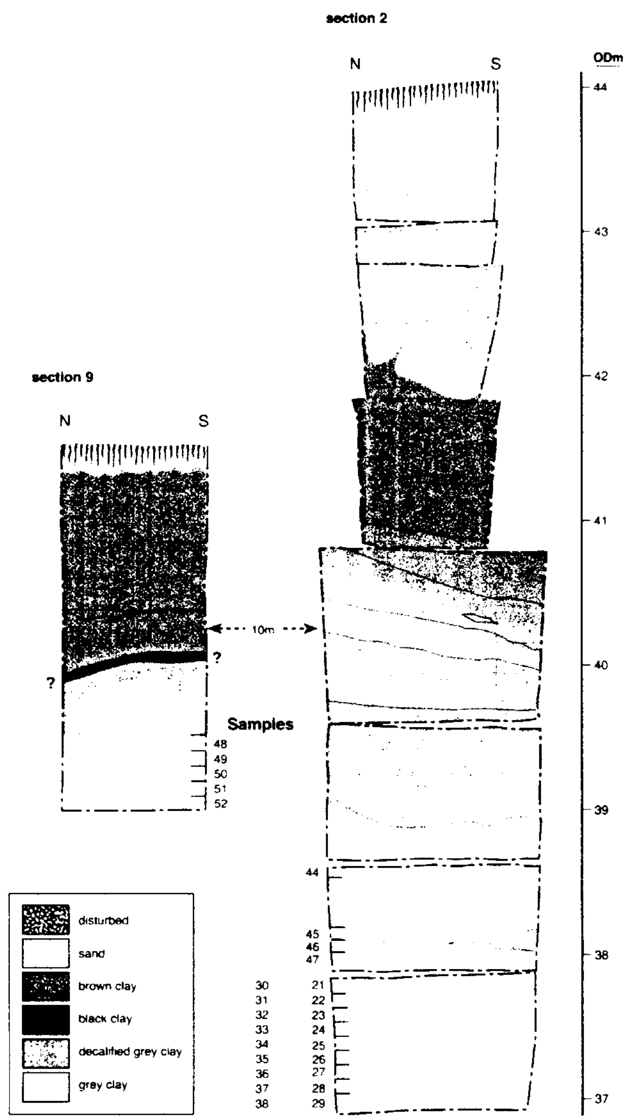


Fig 15.
Sections 2 and 9 showing position of vertebrate samples (21–9 and 44–52) and molluscan samples (30–8).

PALYNOLOGY

(GNT)

Samples for pollen analysis were taken from bed 2 in Areas I, II, and IV, from Section 2 and from a core taken from the base of Test Pit 1. Only the samples from the core contained pollen. The 0.5 m of basal clays above the till contained no pollen, but pollen was well preserved in the overlying 4.5 m of black organic silts and clays. The overlying grey clay again contained no pollen.

The method of pollen extraction was based on that outlined by Barber (1976). Coarse interval pollen analysis was performed. Countable pollen was not found at all levels and some samples proved to be barren. Two pollen assemblage biozones can be defined and some significant changes can be determined through the sequence (Fig. 16).

Biozone E1: Pollen statigraphy

The base of the sequence is characterised by high frequencies *of Hippophaë* (rising to 58% TLP) and Poaceae (62% at the base, falling to 20–30% above). A steady rise in the frequency of *Betula* through this biozone is matched by the decline of Poaceae. Pollen of *Pinus*, *Corylus*, *Salix*, and *Juniperus* is also recorded together with low frequencies of several open-ground herb taxa, including *Thalictrum*, Caryophyllaceae, and Lactuceae pollen. Other herbaceous taxa and lower plants are poorly represented at levels of < 2%. Total pollen concentrations were uniformly low at between 3 x 10^3 and 8 x 10^3 grains/cm^3 through the sequence. Counts of indeterminable pollen, including degraded and broken grains, were high (range 20–38% TLP + indeterminables).

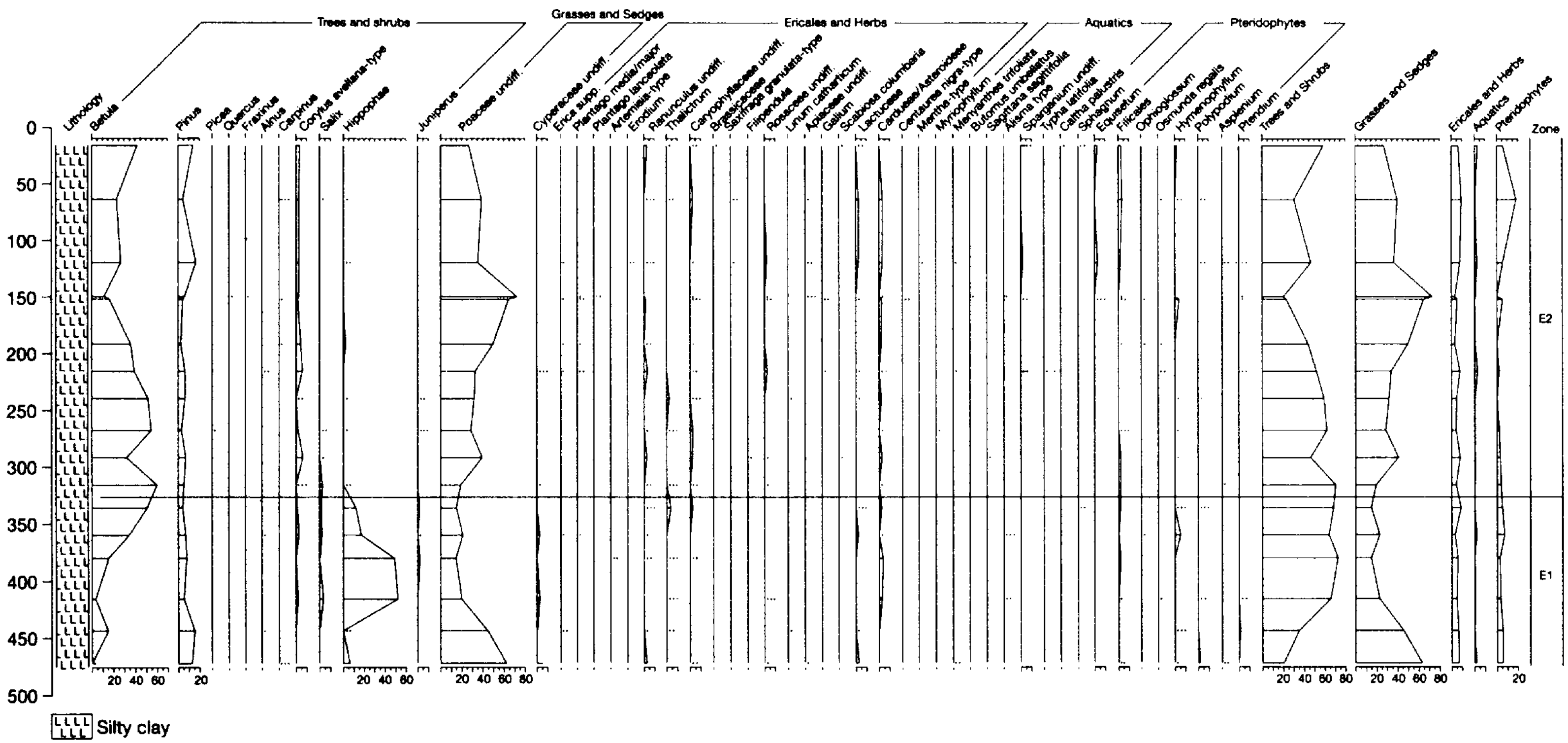


Fig 16.
Pollen diagram through bed 2 borehole 95/2 in Test Pit 1.

E1: Vegetation history

The presence of *Hippophaë*, together with the lithological evidence, indicates the transition from glacial to interglacial conditions. *Hippophaë* has long been thought to be characteristic of Late Anglian and Early Hoxnian substages (Turner 1970). It is a plant intolerant of shade and characteristic of open habitats, so it is likely that the vegetation cover remained incomplete. Open habitat communities with *Thalictrum*, Caryophyllaceae, and Lactuceae, were comparatively well developed during most of this period, reflecting the open nature of the tree cover.

The early appearance and increasing dominance of *Betula* indicates a fairly rapid transition from cold, glacial conditions to a warmer environment in the latter part of the biozone. In stands of woodland, *Betula* was associated with *Pinus* and *Corylus*. Drier areas supported some *Juniperus* scrub. The increase in arboreal pollen suggests the replacement of open vegetation by trees.

The high frequencies of crumpled and degraded pollen grains found throughout this biozone may be related to the minerogenic nature of the sediments, which could have abraded and degraded some of the pollen during transport.

Biozone E2: Pollen stratigraphy

The base of this biozone is placed at the sharp decline of the *Hippophaë* curve. The pollen spectra are dominated by *Betula*, which, following a marked increase at the base to reach 70%, fluctuates from 20–35% through the rest of the biozone. Although *Hippophaë* declines sharply at the base, there are sporadic occurrences of single grains throughout this biozone. *Pinus* pollen increases through the biozone, reaching a maximum frequency (20%) at 1.20 m in the upper part of the sequence. Pollen of *Alnus*, *Carpinus*, *Salix*, and *Juniperus* occurs intermittently.

Poaceae pollen frequencies remain high (30–80%) throughout the biozone and a sharp rise in this pollen type mirrors a decline in *Betula* frequencies at *c.* 1.50 m. There is slight increase in the overall diversity and frequency of herbaceous pollen, including Caryophyllaceae, Rosaceae, and Lactuceae, but aquatic plant frequencies remain low at < 1%, with *Sparganium* type pollen accounting for most of this total. Lower plants are shown by low frequencies of *Filicales* and *Hymenophyllum* spores with intermittent occurrences of *Osmunda regalis*, *Pteridium*, and *Polypodium*.

Total pollen concentrations were uniformly low at between 5 x 10^3 and 10 x 10^3 grains/cm^3 through the sequence. Counts of indeterminable pollen, including degraded and broken grains, were high (range 20–30% TLP + indeterminables).

E2: Vegetation history

The increasing dominance of *Betula* through the sequence indicates amelioration from earlier colder conditions. Peaks in frequency of *Betula* pollen at 3.16 m and 2.70 m are associated with maxima of the organic content of the sediments and may indicate periods in which there was increased productivity, or merely a decrease in the minerogenic input to the water body. *Carpinus*, common on clay soils and very characteristic of East Anglian Middle Pleistocene interglacial sequences, is usually a late-temperate taxon and its presence, particularly in the lower part of the sequence, may indicate reworking. Records of single grains of *Picea* and *Quercus* pollen, at 1.50 m may also be the result of reworking. The presence of *Alnus*, *Salix*, and Cyperaceae pollen indicates damp ground by a pond or stream.

The rise in Poaceae and fall in *Betula* pollen frequencies at *c.* 1.50 m does not correspond with any major changes in the lithology or variation in organic content of the sediments, but is associated with a rise in the diversity and frequency of open ground herbs, suggesting a period in which the forest cover decreased, providing open habitats favourable to the growth of herbs and grasses. Following this rise in non-arboreal pollen there is evidence of re-expansion of *Betula*, with *Pinus* assuming increasing importance in the forest community. The pollen spectra of this biozone share similarities with those of substage IIa at Hoxne (West 1956), in which there was a similar peak of non-arboreal pollen (mostly grasses) and decline in *Betula* forest. This is distinct from the widely recognised non-arboreal pollen phase of substage IIc.

Herbs are rare in the pollen spectra but open ground herbs, including Lactuceae and Caryophyllacae, together with the shrub *Hippophaë*, persist to the end of the sequence, reflecting the continued presence of small areas of open habitats. Other herbs present are probably associated with wet ground near a water body or slow moving water; they include, *Thalictrum*, *Sparganium* and *Alisma*. The pollen assemblage is indicative of open vegetation growing in damp, poorly drained, base-rich soils at the edge of a water body.

Faunal evidence from sediments above the polleniferous layers (see below) suggests that dense vegetation surrounded the water-body. However, only the early part of the interglacial is represented in the pollen succession and although *Betula* and *Pinus* are present, mixed oak woodland is not recorded. However, the increase in arboreal pollen through the sequence suggests a trend towards such woodland development.

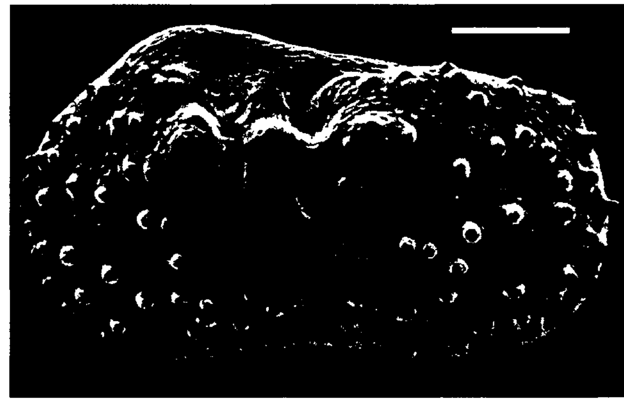


Fig 17.
Ilyocypris quinculminata Sylvester-Bradley, 1973. Adult left valve, from bed 2 (grey clay/silt), section 9, sample 50. This species is not known from post-Hoxnian sites. Scale bar = 200 μm.

OSTRACODS

(JEW)

Samples were not collected for freshwater ostracods *per se*, but were picked out from small vertebrate residues after sieving through a 500 μm mesh. Because the sieve used was rather coarse, it must be expected that all but the larger ostracod species would be lost. For this reason no quantitative data can be given and the distribution given in Table 4 is merely on a presence/absence basis. Twelve samples, nevertheless, yielded ostracods. These were, in descending order in the main sequence, from Section 9, Section 2 and Test Pit 3 (Fig. 15). There was one further sample (19) from Test Pit 1, which came from an adjacent sequence, but unfortunately it is not possible to correlate its position relative to the main sequence above.

Six ostracod species were recovered (Table 4). Of these, five live in Britain today, the sixth, *Ilyocypris quinculminata*, being extinct (Fig. 17). This latter species occurs in all the sections and is almost ubiquitous in all the samples. *Prionocypris zenkeri* is found only in Sections 9 and 2, as is *Ilyocypris gibba* and *I. bradyi*. *Herpetocypris reptans* occurs at the base of Section 9 and throughout Test Pit 3, whilst *Fabaeformiscandona balatonica* occurs only in Section 2 and Test Pit 3.

All the ostracod species indicate a permanent waterbody. The living species of *Ilyocypris* are found today in slowly moving water, as they cannot swim; perhaps *I. quinculminata* had similar requirements. *Herpetocypris reptans* also occurs in slow streams and rivers with rich vegetation and muddy bottoms on which it crawls. *Prionocypris zenkeri*, again, prefers slow-flowing clean streams with rich aquatic vegetation (often including dense charophyte mats) and positively avoids both deep and stagnant waters. *Fabaeformiscandona balatonica*, on the other hand, prefers the swampy areas and shallowest edges of streams. This low diversity fauna may be an artefact, smaller species being missing because of sample procedure. Nevertheless, it still gives a useful indication of the palaeoenvironment of the Elveden

TABLE 4: OSTRACODA FROM ELVEDEN. X INDICATES PRESENCE IN SAMPLE

Section/Test Pit	*Section 9*			*Section 2*				*TP3*				*TP1*
Sample	*49*	*50*	*52*	*44*	*45*	*46*	*43/47*	*13*	*14*	*15*	*16*	*19*
Ilyocypris quinculminata Sylvester-Bradley, 1973	x	x	x	x	x	x		x		x		x
Prionocypris zenkeri (Chyser & Toth, 1985)		x		x	x	x	x					
Ilyocypris gibba (Ramdohr, 1808)		x	x			x	x					
Herpetocypris reptans (Baird, 1835)			x					x	x	x	x	
Ilyocypris bradyi Sars, 1890				x	x		x					
Fabaeformiscandona balatonica (Daday, 1894)				x			x	x	x			

sequence. It appears to have been deposited by (at most) a slow-flowing river or stream. The water was clean with rich aquatic vegetation, and there is some indication of a bordering swamp.

The presence of *Ilyocypris quinculminata* has considerable age-significance. It was originally described by Sylvester-Bradley (1973) from Lowe's Pit, Trysull, Staffordshire, central England, which is of Hoxnian age. Since then it has been found from five other Hoxnian sites in the UK (Copford, Essex; Froghall, Warwickshire; Hatfield, Hertfordshire; Hoxne, Suffolk; and Marks Tey, Essex), and four Cromerian sites (Boxgrove, West Sussex; Little Oakley, Essex; Waverley Wood Pit, Warwickshire; and Sidestrand, Norfolk). It is also known in Germany, at three Holsteinian sites (Bilzingsleben, Thuringia; Wildshütz, Saxony; and Wohnbach, Hesse) – (Griffiths 1995; personal collections of J.E. Whittaker). The occurrence of *I. quinculminata* at Elveden, therefore, indicates a Middle Pleistocene age of no younger than Marine Isotope Stage (MIS) 11.

MOLLUSCA

(DHK)

Samples for Mollusca were collected from the grey silt/clay at the base of Section 2 (Fig. 15). The samples of 10–15 kg bulk were washed through sieves to 500 μm and oven dried at 40°C for sorting. The counting conventions follow those of Sparks (1961) where each gastropod is noted as a single individual, and each bivalve shell with intact cardinal dentition is recorded as 0.5 of an individual. The fauna is listed in Table 5 using the taxonomic nomenclature of Kerney (1999).

The condition of the Mollusca was very poor in all samples due to partial decalcification, with many reduced to fragments and with very few whole or adult shells preserved. The majority of the shells were present in the lower 40 cm of the profile of Section 2. The top 40 cm lacked any molluscan content other than opercula of *Bithynia tentaculata*, preserved because they are made of relatively stable calcite rather than unstable aragonite, and fragmented hingelines and umbones of *Pisidium* spp., preserved because these are the most robust shell elements. A number of specimens of *Pisidium* were preserved as internal casts, in each case by cementation of the sediment infill of the valves originally held together at burial by the ligament. Because of the poor state of the fossils, identification was often difficult, especially with the *Pisidium* spp., whose corroded hinge-plates or umbones were mostly only identifiable to generic level (Table 5).

Environmental indications

Sixteen molluscan species are represented. They are overwhelmingly aquatic in habitat, although terrestrial Mollusca are present in the form of a single slug plate, two shells of *Vallonia* sp., and a fragment of *Discus* sp. The assemblage is dominated by valves of *Pisidium* spp., and the shells and opercula of *Bithynia tentaculata*.

Although the vast majority of *Pisidium* valves could only be identified to genus (see Table 5), seven species were recorded. The occurrence together of the river group of *Pisidium* species (*P. amnicum*; *P. clessini*; *P. henslowanum*, and *P. moitessierianum*) suggests that deposition occurred in a moderate sized river. Slow moving water is also suggested by the occurrence of the gastropod species *B. tentaculata* and *Valvata piscinalis*.

The presence of the pond species *Sphaerium corneum*, *Pisidium nitidium*, *P. subtruncatum*, and *Gyraulus crista* might be thought to indicate still water, but all of these may be found in the slower flowing, quiet reaches of rivers as well as ponds. The presence of *Valvata cristata* and *G. crista* suggests that the river had muddy, vegetation-rich water, the preferred habitat of these two species.

The very small land component of the fauna makes firm comment about the terrestrial environment difficult. However, snails of the genus *Vallonia* live in grassland and marsh, both of the possible species of *Discus* prefer shade habitats in woods or scrub, and slugs of the genus *Limax* are found in most damp environments from marshes to woodland edges (Kerney & Cameron 1979).

The high ratio of *Bithynia* opercula to shells might suggest fluvial sorting and thus fairly strong current activity. The imbalance is even more noticeable when it is recognised that all of the shells of the genus are tiny juveniles, while at least 50% of the opercula are from adult shells. This '*Bithynia* ratio' has been noted by Gilbertson and Hawkins (1978) and Horton *et al.* (1992) and used as an indication of current action, as the hydrodynamic properties of the opercula are different to those of the shells. Other indications of

TABLE 5: MOLLUSCA FROM ELVEDEN GREY SILT/CLAY

Section/Test Pit	*Section 2*										*Section 2*	
sample	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*38*	*41*	*1996 no number*	*4*	*5–7*
Freshwater Mollusca												
Valvata cristata Müller, 1774												1
V. piscinalis (Müller, 1774)					1	2			2	1		14
Bithynia tentaculata (Linné, 1758)					4	9	1	2	11	1	11	60
B. tentaculata opercula*	2	12	6	23	28	55	14	12	36	21	56	179
Lymnaea spp.						1						
Gyraulus crista (Linné, 1758)						1						2
Sphaerium corneum (Linné, 1758)											1	1
Pisidium amnicum (Müller, 1774)												1
P. clessini Neumayer, 1875						1			1			
P. casertanum (Poli, 1791)					1							
P. subtruncatum Malm, 1855								1	2			10
P. henslowanum (Sheppard, 1823)												1
P. nitidum Jenyns, 1832					2						1	3
P. moitessierianum Paladilhe, 1866								1				
Pisidium spp.			2	6	11	16	7	26	4	1	14	377
Land Mollusca												
Vallonia spp.			1							1		
Discus spp.										1		
Limax spp.												1
Total (3 land, 13 freshwater taxa)	0	0	3	6	19	31	8	30	56	5	27	471

* Opercula of *B. tentaculata* not included in the totals

intensity of fluvial flow in the Elveden fauna, such as the paired valves of *Pisidium*, however, suggest that high-energy flow conditions were rare. The imbalance between shells and opercula might therefore be mainly due to the greater resistance of the latter to decalcification.

Molluscan assemblages with fewer than 20 taxa present are often interpreted as being from cool or cold climates in the British Pleistocene as there is a marked reduction in numbers of molluscan species towards the Arctic Circle (Keen 1987). In addition, many of the molluscan species in the Elveden fauna are not climatically diagnostic. However, *P. amnicum*, *P. clessini*, *P. henslowanum*, and *P. moitessierianum* are only found in fully temperate conditions in Britain (Ellis 1978), and the single fragment of *Discus* also indicates some warmth, as both species of this genus found as fossils in the British Pleistocene are exclusively interglacial in their distribution. There are no species in the fauna which are indicators of other than temperate conditions, so the balance of the evidence indicates an interglacial environment with the relatively small numbers of species explained by the poor conditions for preservation at Elveden.

In summary, the local conditions as indicated by the Mollusca were of a temperate, slow-flowing river with considerable macrophytic vegetation, and grassland and scrub or woods on its banks in a temperate environment.

Indications of age

The fauna suggests little about the age of the site as most of the species present have ranges from the Middle Pleistocene to the Holocene. However, the presence of *P. clessini* indicates an age no younger than MIS 7 (Keen 2001). This species is present in Britain from the Cromerian of the West Runton Forest Bed (Sparks 1980) to later Middle Pleistocene times. Its last appearance is in the MIS 7 deposits of the Thames in Essex (Preece 1999; Keen 2001). It is now totally extinct.

VERTEBRATES
(SP)

Samples were taken for vertebrate remains from the upper 2 m of the grey silt/clay. These were wet-sieved through a 500 μm mesh and the residues were dried and sorted for vertebrate remains. In addition, the occurrence and abundance of other remains, such as molluscs, ostracods, charophytes, and mineralised plant remains were noted. In total, 1046 kg of sediment was sieved from the column sequence in Section 2 and Test Pit 3. A further large sample of approximately 500 kg was processed from the very top of the grey silt/clay, immediately below the undulating decalcification front in Section 9. Vertebrate remains were not particularly common in any of the samples and those from the lower part of the sequence were often completely barren.

The clays contained a relatively diverse fish fauna including cyprinids (roach *Rutilus rutilus*, tench *Tinca tinca* and rudd *Scardinius erythrophalmus*), pike (*Esox lucius*), perch (*Perca fluviatilis*), and three-spined stickleback (*Gasterosteus aculeatus*). As an assemblage, the fish are indicative of a large body of well-oxygenated, slow-flowing or still water with a rich aquatic flora. A temperate environment is indicated by the cyprinids, which have a minimum requirement for spawning and larval development (Wheeler 1977). Today, rudd and tench have a southerly distribution with a northern limit that coincides with 15°C July mean isotherm, and their presence in the upper part of the grey silt/clay reflects warm summer water temperature. The abundance of fish bones increases up the profile, perhaps an indication of a richer aquatic environment, but other factors such as changes in sedimentation rate may account for this trend. A partial pike skeleton excavated from Section 2 (same level as sample 22) indicates rapid burial and possibly anoxic conditions at the bottom of the waterbody. This preservation is exceptional; skeletal material through the rest of the sequence consists of isolated and rather fragmertary remains, predominantly single pharyngeal teeth, vertebrae, and other bones, and occasional scales.

A progressive decrease in the relative frequency of fish bones towards the top of the sequence is associated with successive increases in firstly the number of amphibian bones, and secondly small mammal remains. This trend, illustrated in Figure 18, probably reflects the infilling of the water body and the encroachment of dry-land conditions, a conclusion supported by the presence of small nodular carbonate concretions (pedogenic in origin) and calcareous root traces (rhizoconcretions) in the upper part of the sequence (see above). The occasional specimens of small mammals could have been washed in through runoff or floodwaters from the nearby banks. Unfortunately, the amphibian and small mammal assemblages are far too sparse and fragmentary to provide any ecological or biostratigraphical interpretation. Nevertheless, the presence of pygmy shrew *Sorex minutus*, a microtine rodent *Microtus* sp., water vole *Arvicola* sp., and mouse *Apodemus* sp., may suggest dense vegetation in the immediately surrounding environment.

Unfortunately vertebrate remains did not survive in the non-calcareous fluvial and colluvial deposits, which were the focus of the archaeological excavations (Areas I–V) overlying the lacustrine grey clays. Decalcification has affected these deposits and the upper part of the lacustrine clays in all of the sections and boreholes where they were encountered.

PALAEOENVIRONMENTAL SUMMARY

The biological remains from the site show a basin that infilled during a late glacial episode and into the following warm period. Pollen, particularly that of *Hippophaë*, from the lower part of the grey silt/clay indicates cool open habitats. A transition to slightly warmer conditions is shown by the early appearance of *Betula*, which with *Pinus* and *Corylus* also increase up the sequence. Although the pollen records a trend towards woodland development, fully temperate mixed oak forest is not recorded. Rather, the pollen suggests cool climatic conditions with still open vegetation growing in damp, poorly drained, base-rich soils at the edge of a water body.

The faunal evidence which was recovered from sediments overlying the pollen sequence records fully temperate conditions. Warm climate is indicated by the molluscs, *Pisidium amnicum*, *P. clessini*, *P. henslowanum*, and *P. moitessierianum*, while a temperate environment is also indicated by the cyprinids, which have a minimum water temperature requirement of 15°C for spawning and larval development. By this point slow-flowing, well-oxygenated water is suggested by all the ostracods from the site that are still extant, but also by the river

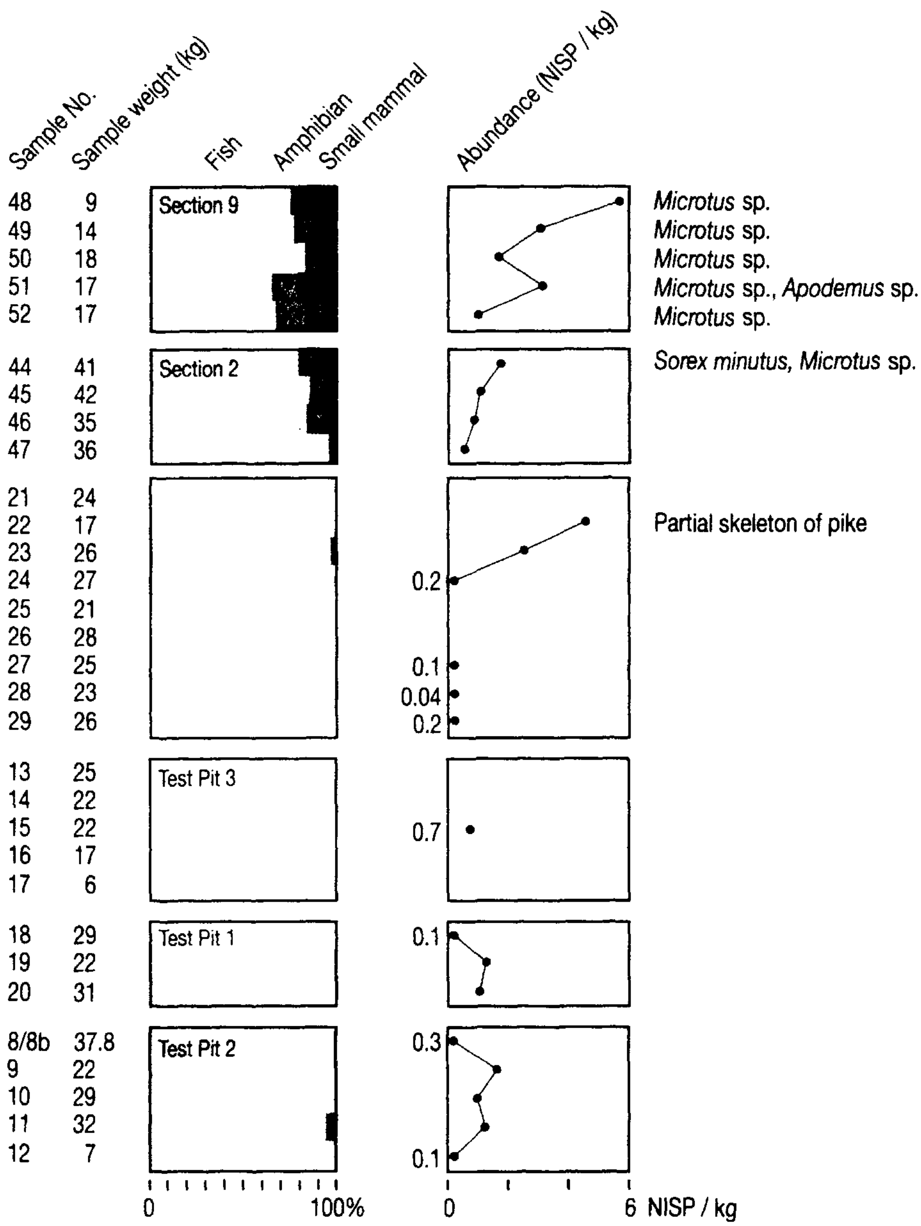


Fig 18.
Weights, ratios, and abundance of vertebrates in samples from Sections 2 and 9, and Test Pits 1, 2 and 3. Section 9, Section 2 and Test Pit 3 are in approximate stratigraphic order.

group of molluscs (*P. amnicum*, *P. clessini*, *P. henslowanum* and *P. moitessierianum*) which suggest the presence of a moderate sized river.

Very occasional remains of amphibians and mammals at the top of the sequence might suggest a silting-up of the river channel towards the top of the grey, silt/clay. This is supported by the carbonate concretions within the sediment, which indicate pedogenesis. Such channel infill sequences are common in Middle Pleistocene fluvial contexts in central England (Shotton *et al.* 1993; Green *et al.* 1996: Keen *et al.* 1997).

AMINO ACID GEOCHRONOLOGY

(KP)

Amino acid racemisation (AAR) analyses were undertaken on seven *Bithynia tentaculata* opercula – five from samples 4 and 5 from Section 2 (NEaar 1568–1572) and two from sample 36 also in Section 2 (NEaar 1573–1574). All samples were prepared using the procedures of Penkman (2005). In brief, each operculum was powdered and bleached for 48 hours with 12% NaOCl. Two subsamples were taken: one fraction was directly demineralised and the free amino acids analysed (referred to as the 'Free' fraction, F), and the second was treated with 7M HCl at 110°C for 24 hours (referred to as the 'Hydrolysed' fraction, H) to release the peptide-bound amino acids. Samples were then dried by centrifugal evaporator and rehydrated for HPLC analysis with 0.01mM L-homo-Arginine as an internal standard.

The amino acid compositions of the samples were analysed in duplicate by reverse-phase HPLC using fluorescence detection following the method of Kaufman and Manley (1998). 2 µl of sample is injected and mixed online with 2.2 µl of derivitising reagent (260mM *n*-Iso-L-butyryl L-cysteine (IBLC), 170 mM o-phthaldialdehyde (OPA) in 1M potassium borate buffer, adjusted to pH 10.4 with potassium hydroxide pellets). The amino acids are separated on a C_{18} HyperSil BDS column (5 mm * 250 mm) at 25°C using a gradient elution of three solvents: sodium acetate buffer (solvent A; 23 mM sodium acetate tri-hydrate, 1.5 mM sodium azide, 1.3 µM EDTA, adjusted to pH 6.00±0.01 with 10% acetic acid and sodium hydroxide), methanol (solvent C) and acetonitrile (solvent D). The L and D isomers of twelve amino acids were routinely analysed. During preparative hydrolysis both asparagine and glutamine undergo rapid irreversible deamination to aspartic acid and glutamic acid respectively (Hill 1965). It is therefore not possible to distinguish between the acidic amino acids and their derivatives and they are reported together as Asx and Glx. The DL ratios of glutamic acid/glutamine, aspartic acid/asparagine, serine, alanine, phenylalanine and valine (D/L Asx, Glx, Ser, Ala, Phe, Val) are then combined to provide an overall estimate of protein decomposition using the degradation model kinetic (current version DMK v2.0).

On the basis of the relative DL ratios and concentrations (Table 6) the amino acid data when compared with unpublished values from sites spanning MIS 5–17 are consistent with an MIS 11 age (Penkman 2005). The other sites attributed to MIS 11 include Swanscombe, Clacton, Beeches Pit, Barnham, Woodston, and Hoxne.

DATING AND CORRELATION

(SL)

A number of lines of evidence can be used to correlate this site both with the regional geological succession and also with the terrestrial and marine chrono

TABLE 6: DATA USED TO DERIVE DEGRADATION MODEL KINETIC (DMK) VALUES

NEaar no.	L-Asx (pmol mg^{-1})	D-Asx (pmol mg^{-1})	L-Glx (pmol mg^{-1})	D-Glx (pmol mg^{-1})	L-Ser (pmol mg^{-1})	D-Ser (pmol mg^{-1})	L-Ala (pmol mg^{-1})	D-Ala (pmol mg^{-1})	L-Val (pmol mg^{-1})	D-Val (pmol mg^{-1})	L-Phe (pmol mg^{-1})	DPhe (pmol mg^{-1})
1568bF	7233	5753	1472	572	1615	1730	9417	4496	5051	1410	1446	1001
1568bH	6265	4207	6634	1917	1503	1083	7489	3790	5299	1164	1588	725
1569bF	8212	6285	1700	672	2458	2449	10900	5873	7649	2201	3653	1628
1569bH	8861	6238	9888	2842	2257	1816	11781	6006	8389	1913	2878	1439
1570bF	7136	5574	1369	547	1546	1612	9486	5039	5207	1503	1685	1122
1570bH	9927	7135	10848	3375	1995	1617	9751	5085	7535	1825	2540	1363
1571bF	4587	3615	885	362	982	1012	7057	3746	3299	939	1004	647
1571bH	6972	5052	8175	2346	2454	2082	10514	5225	8714	2117	3453	1693
1572bF	5829	4536	1145	476	1221	1252	8963	4696	4176	1203	1356	864
1572bH	10404	7471	12558	3563	2361	1978	10732	5282	8695	1893	2993	1616
1573bF	4205	3187	860	351	1511	1262	8894	4529	4333	1183	1418	853
1573bH	8066	5657	9242	2576	2242	1786	10308	5042	8355	1809	3118	1483
1574bF	5945	4698	1197	474	1277	1364	9122	4714	4586	1227	1449	920
1574bH	12156	9024	1362	4015	2373	2221	12177	6147	9689	2194	3338	1721

stratigraphic frameworks. The chalky diamicton is correlated on lithological grounds with the Lowestoft Till Member of the Lowestoft Formation. This unit was deposited by ice during the Anglian Stage of the British Pleistocene and this is, in turn, generally thought to correlate with MIS 12.

Paterson distinguished two till units (Lower and Middle Boulder Clays) in the Breckland on the basis of the presence of Bunter erratics (ie, quartzite and quartz derived from the Triassic pebble beds in the Midlands), which were thought to be present only in the Middle Boulder Clay (Paterson 1942; Paterson & Fagg 1940). Paterson argued that the basal deposit at Elveden was the Middle Boulder Clay as it contained Bunter pebbles, albeit that only two were found (Paterson & Fagg 1940, 4). This could be correlated with the boulder clay overlying the artefact bearing deposits at East Farm, Barnham, thus separating the Barnham and Elveden artefact assemblages into distinct temperate phases, separated by the Middle Boulder Clay. Detailed analysis of the tills at East Farm Barnham revealed, firstly, that no till unit could be convincingly demonstrated overlying the artefact-bearing deposits and that there was no systematic variation in clast lithological composition, allowing separation of till units on the presence/absence of quartzite and quartz (Lewis 1998). Furthermore, the frequency of quartz and quartzite in the chalky diamicton at Elveden is similar to tills at East Farm, Barnham that were regarded as the Lower Boulder Clay by Paterson (1937). Therefore there is no robust basis for distinguishing two till units in the Breckland and the chalky tills present at Elveden and Barnham can be regarded as a single lithostratigraphic unit, the Lowestoft till, and the product of a single glacial episode.

The overlying deposits of beds 2–4 may reasonably be placed in the Hoxnian Stage as they occupy a depression in the surface of the chalky till, which would have formed a water body in which sediment was deposited during the warm episode immediately following deglaciation at the end of the Anglian. This attribution is supported by the amino acid geochronology, where ratios are consistent with other sites correlated with MIS 11 (see above).

Biostratigraphic information to support a correlation with the Hoxnian is limited due to the small quantity of faunal material recovered from bed 2. The palynology of the organic deposits within bed 2 does support a correlation with the Hoxnian, in particular the presence of *Hippophaë* at the base of the sequence and the rise in non-arboreal pollen in p.a.b.E2 are characteristic of Hoxnian pollen assemblages. There is an increasing body of evidence including absolute age estimates to suggest that most sites with Hoxnian pollen and fauna can be attributed to MIS 11 (Preece *et al.* in prep).

ARCHAEOLOGY
(NA)

TAPHONOMY OF THE FLINT ASSEMBLAGES

The study of the post-depositional movement and damage to artefacts, now commonly termed taphonomy, has become an important aspect of lithic analysis, and is essential for understanding the effects that the natural environment has on archaeological assemblages (Isaac 1967; Shackley 1974; Rick 1976; Schiffer 1983; Schick 1986; Chase *et al.* 1994; Dibble 1995; Ashton 1998a). The understanding of these processes forms an essential precursor to the interpretation of any human behaviour at a site, and can be understood through study of the: depositional environment; artefact condition; artefact orientation; spatial distribution and refitting studies; technology; and size distribution. All of these studies were used in the analysis below, other than artefact orientation. As with Barnham (Ashton 1998a), the virtual absence of elongated pieces (length: width ratio of 2:1) made the use of this type of analysis statistically invalid.

The principal artefact bearing deposits at Elveden were mainly laid down under fluvial conditions, although the more dispersed artefacts from higher up the sequence were mainly found in colluvial or solifluction deposits. The exception is the main assemblage from Area III, which was associated with a landsurface.

The site was excavated in five main areas producing eight artefact assemblages (Table 7). The two principal areas (I and III) provided four assemblages and will be dealt with using the full range of taphonomic studies. The remaining areas (II, IV, and V) are small in artefact numbers and are best understood in terms of the conclusions drawn from the study of Areas I and III.

Area I

The taphonomy of the assemblages from Area I is complex with material recovered from both in and on

TABLE 7: TOTALS AND PERCENTAGES (WITH AND WITHOUT CHIPS) OF ARTEFACTS FROM THE DIFFERENT ASSEMBLAGES

	Area I		*Area II*	*Area III*		*Area IV*	*Area V*	
	Brickearth	*Gravel*	*Gravel*	*Black clay*	*Brickearth*	*Gravel*	*Black clay*	*Gravel*
Bifaces	0	1	1	0	0	1	0	0
Biface roughouts	0	1	2	4	0	2	1	1
Soft hammer flakes	146	25	7	274	63	10	10	9
Cores	14	7	4	22	3	4	1	1
Flake tools	3	4	0	6	2	0	0	0
Hard hammer flakes	369	224	64	372	104	114	30	45
knapping fragments	55	11	5	13	17	6	2	4
Chips	1576	201	181	774	39	61	102	34
Total	2163	474	264	1465	228	198	146	94
Percentages								
Bifaces	0.0	0.2	0.4	0.0	0.0	0.5	0.0	0.0
Biface roughouts	0.0	0.2	0.8	0.3	0.0	1.0	0.7	1.1
Soft hammer flakes	6.7	5.3	2.7	18.7	27.6	5.1	6.8	9.6
Cores	0.6	1.5	1.5	1.6	1.3	2.0	0.7	1.1
Flake tools	0.1	0.8	0.0	0.4	0.9	0.0	0.0	0.0
Hard hammer flakes	17.1	47.3	24.2	25.4	45.6	57.6	20.5	47.8
knapping fragments	2.5	2.3	1.9	0.9	7.5	3.0	1.4	4.3
Chips	72.9	42.4	68.6	52.8	17.1	30.8	69.9	36.2
Percentages without chips								
Bifaces	0.0	0.4	1.2	0.0	0.0	0.7	0.0	0.0
Biface roughouts	0.0	0.0	2.4	0.6	0.0	1.5	2.3	1.7
Soft hammer flakes	24.9	9.2	8.4	39.5	33.3	7.3	22.7	15.0
Cores	2.4	2.6	4.8	3.2	1.6	2.9	2.3	1.7
Flake tools	0.5	1.5	0.0	0.9	1.1	0.0	0.0	0.0
Hard hammer flakes	62.9	82.4	77.1	53.7	55.0	83.2	68.2	75.0
knapping fragments	9.4	4.0	6.0	1.9	9.0	4.4	4.5	6.7

the gravel, but also from at least 1 m of the 'brickearth' above (Fig. 5). The gravel context is interpreted as a lag and artefacts occur on and within this unit. The gravel also mantles swirl hollows, in which artefacts were additionally found. These are similar to those described in Area II (see above). Given this type of context it is likely that the artefacts have moved. The 'brickearth' above is slightly more complex. This has been interpreted as a largely colluvial deposit, although there may be thinly developed soils within it. A poorly developed soil could be seen in section immediately above the gravel, although this was very difficult to trace during excavation. Whether the artefacts in the 'brickearth' are *in situ* or not needs to be more fully explored, as does the question of whether they could be derived from the underlying gravel.

The majority of the artefacts from the gravel are slightly to moderately rolled, a high proportion are scratched, and they are moderately patinated and generally quite stained (Fig. 19). There is a notable difference with those from the 'brickearth', which are generally less rolled and scratched, distinctly more patinated, and less stained. This evidence might suggest two separate assemblages, although it should be noted that there is undoubted overlap, with fresh and rolled artefacts occurring in both contexts.

An alternative suggestion is that all the artefacts originate from on or within the gravel, with their condition varying according to the length of time in that context. Subsequently, both rolled and particularly the more recent fresh elements were moved by post-depositional processes (fluvial movement, colluviation) into the 'brickearth'. The angle of slope of the gravel towards the centre of the channel (in places 15°; Fig. 9) is quite sufficient for artefacts to have been moved downslope from a lower into a higher stratigraphic unit over a short distance. If this was the case then a division of both

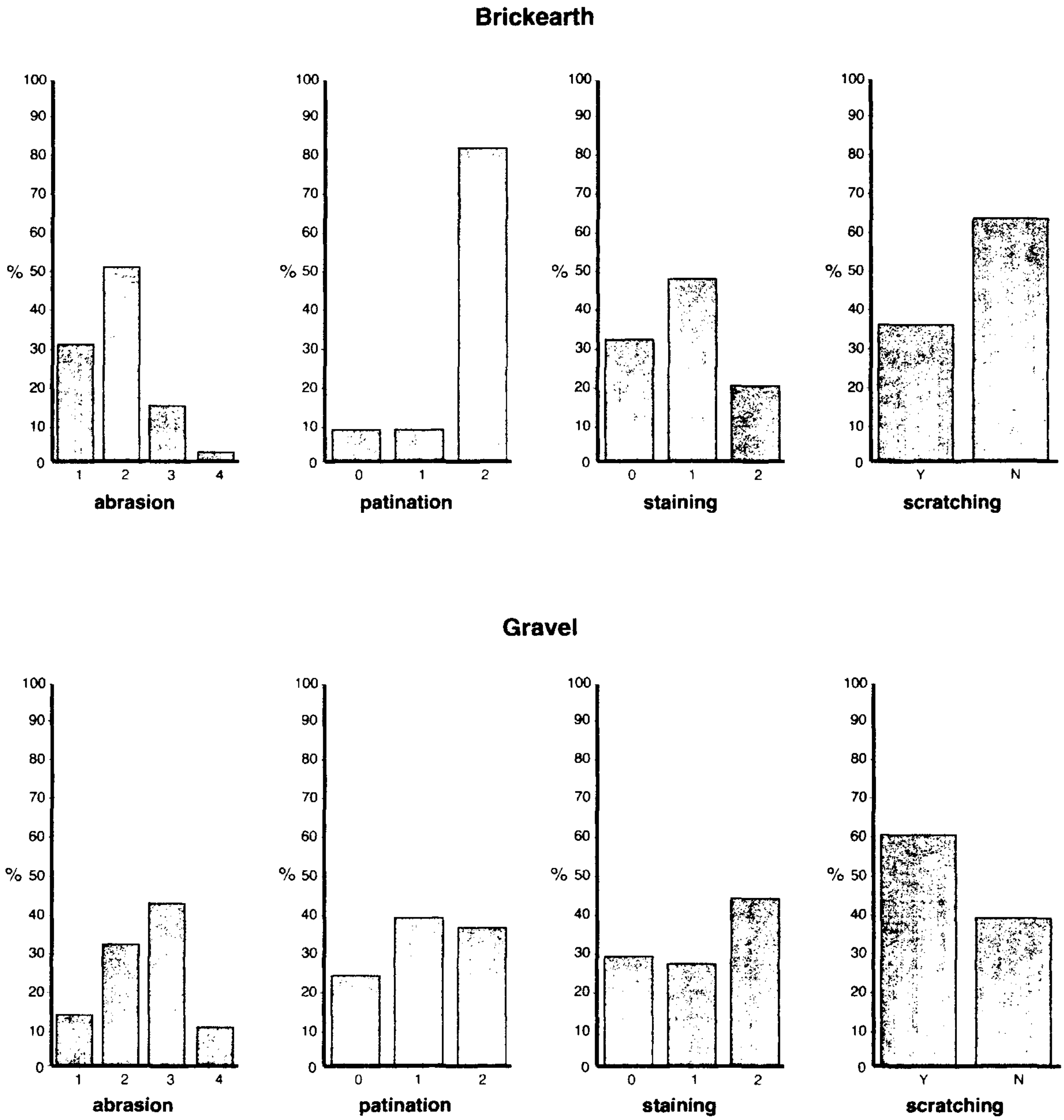


Fig 19.
Percentages of abrasion, patination, staining and scratching on the artefacts from the 'brickearth' and gravel in Area I. Key: *abrasion:* 1 = unabraded; 2 = slightly abraded; 3 = moderately abraded; 4 = very abraded. *Patination:* 0 = unpatinated; 1 = patinated; 2 = very patinated. *Staining:* 0 = unstained; 1 = stained; 2 = very stained. *Scratching:* Y = scratched; N = unscratched.

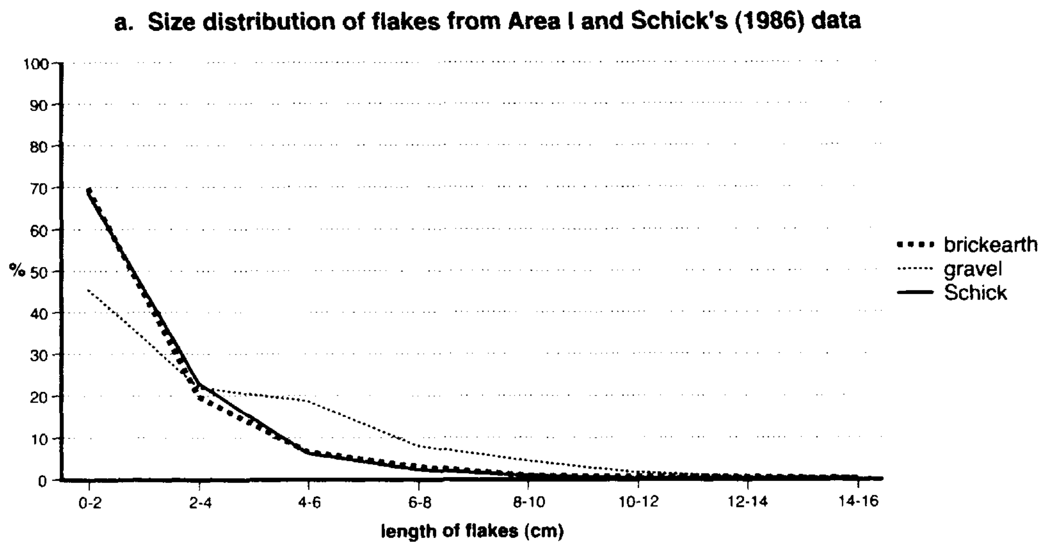
assemblages into fresher and more rolled groups would provide an approximation of earlier and later activity at the site. This is investigated below.

The spatial distribution and refitting studies have contributed little to the understanding of the assemblages. There is little clustering of artefacts. The small number of refits suggests that the artefacts are not *in situ*. The refits consist of two pairs, one of which is a break (from the gravel) and the other a dorsal to ventral refit (from the 'brickearth').

Fig 20.
Proximal and distal refitting flake (P1995.1-2. 483 and 501) from Area I, showing extensive abrasion after breakage.

However, of importance is the very rolled condition of the pair of refits from the gravel. The distance between the distal and proximal parts of the refit was 1.6 m, and the rolling clearly occurred after the break (Fig. 20). A refit of two rolled flakes (dorsal to ventral refit) was also found in a similar context at Barnham, less than 35 cm apart (Ashton 2004). The usual interpretation of this type of damage would be viewed as reflecting considerable fluvial movement, but the chances of two separate refits surviving any significant movement must be remote. The implication is that the artefacts sustained the damage, more or less in place, presumably, rattling against the gravel of which they formed a part, over some length of time. This has important implications for the interpretation of rolled assemblages and their relationship to the wider landscape (see discussion, below).

As would be expected in a gravel context, the size distribution of the artefacts from this layer suggests under-representation of the smaller element (Fig. 21). The most obvious explanation is that this has been winnowed off, presumably by fluvial action. However, it should also be noted that there is inevitably a contribution made by excavation bias; the difficulty of recognising small chips (< 2 mm maximum dimension) in a gravel context, particularly when some are rolled will also contribute to an under-representation of this size category. The important part of the graph is the data from the 'brickearth'. Here the profile suggests that virtually all the assemblage is present. Chips for example account for almost 70% of the assemblage. All the results compare remarkably well with Schick's (1986) original analysis of experimental data. Her data showed an exponential increase of artefact numbers of a smaller size in *in situ* assemblages. The interpretation of the 'brickearth' as a colluvial sediment would imply disturbance. This, however, would not necessarily produce size-sorting of artefacts, but simply redistribution.



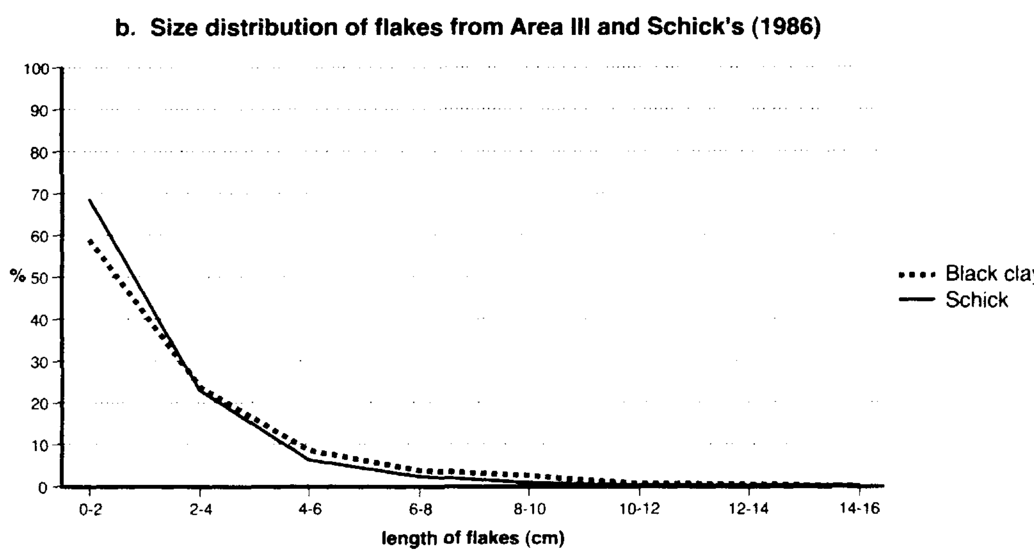


Fig 21.
Size distribution of flakes from Area I 'brickearth' and gravel, and of flakes from Area III black clay compared to Schick's (1986) experimental data.

TABLE 8: PERCENTAGES OF HARD AND SOFT HAMMER FLAKES IN FRESH AND ROLLED CONDITION FROM AREA I

	Fresh Area I			*Rolled Area I*		
	Gravel	*Brickearth*	*Gr + BE*	*Gravel*	*Brickearth*	*Gr + BE*
Hard hammer flakes	83	67	70	96	93	95
Soft hammer flakes	17	33	30	4	7	5
Total	115	423	538	134	92	226

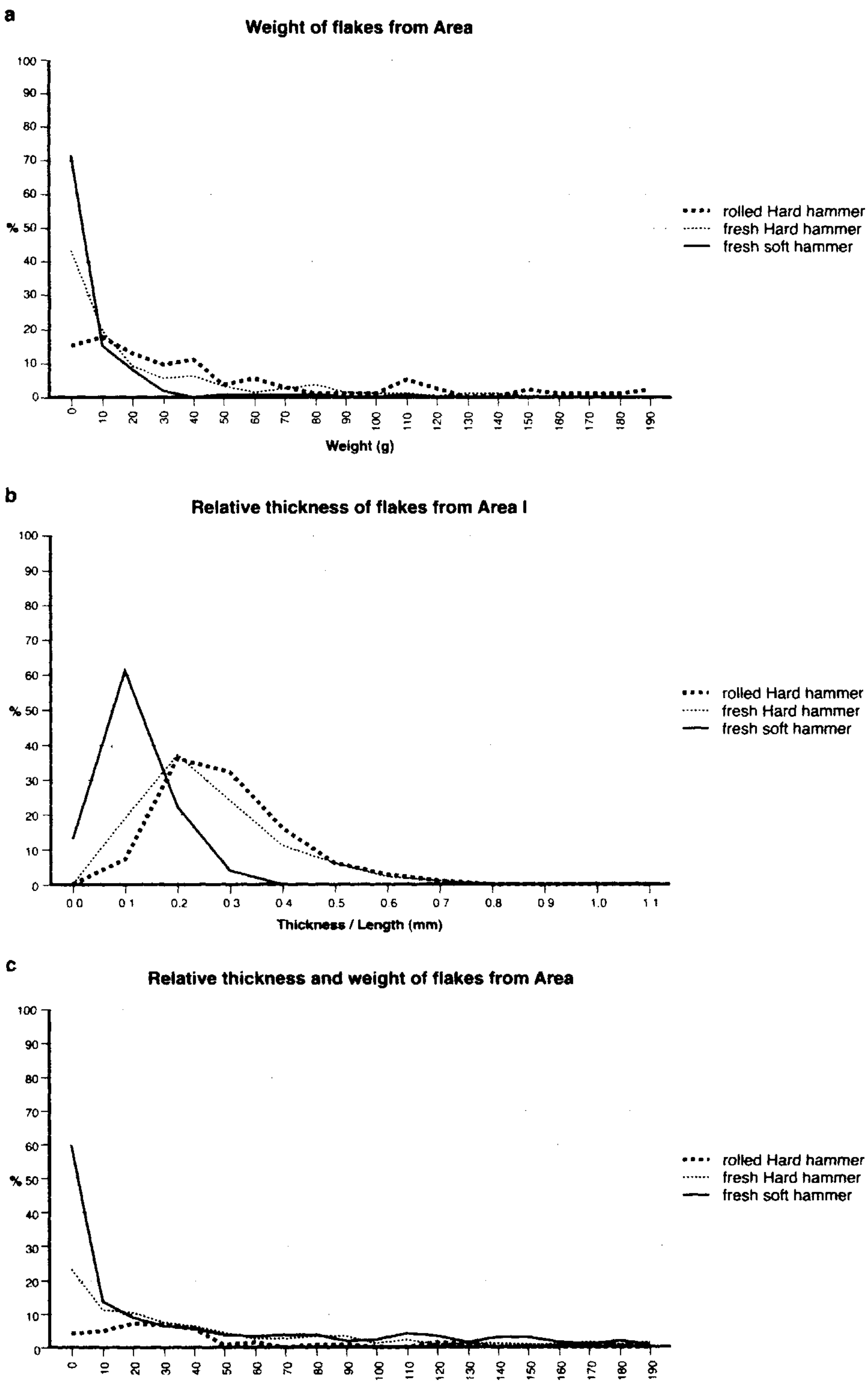


Fig 22.
Weight (a), relative thickness (b), and relative thickness and weight (c) of flakes from the gravel and 'brickearth' in Area I. Flakes are divided into: rolled hard hammer; fresh hard hammer; and fresh soft hammer.

The significance of the difference between the assemblages from the gravel and the 'brickearth' can be tested through technology. The most basic technological distinction is between the soft hammer and hard hammer debitage. As Table 7 shows, there is a marked difference between the assemblages from the gravel and 'brickearth', with little soft hammer debitage in the gravel when chips are excluded from the totals. On face value this would support the distinction between the two assemblages. However, this needs to be investigated in the light of the suggestion above, that the assemblages could be divided into fresher and more rolled elements.

Analysed on this basis with fresh (conditions 1 and 2) and rolled (conditions 3 and 4) groups then the distinction between the two technological groups becomes even more marked (Table 8), with very little soft hammer debitage in the rolled group. This in itself supports the division of the gravel and 'brickearth' assemblages into fresh and rolled groups. It suggests that the earliest knapping at the site was largely core- and flake-working, whereas with later knapping, biface manufacture was also important. Indeed some researchers could reasonably take this as support for a division between a non-biface, Clactonian assemblage, followed by an Acheulian assemblage.

However, the situation is not necessarily quite that simple. An alternative interpretation is that the smaller, lighter element has been winnowed from the gravel, which would include a lot of the soft hammer debitage. To investigate this further, the weight distributions of the rolled and fresh groups have been compared. The first comparison between rolled and fresh hard hammer flakes indicates that there is a significant lighter element missing from the rolled group (Fig. 22a); the number of artefacts under 10 g is almost 30% higher in the fresh group. A comparison of these figures with the fresh soft hammer flakes indicates that over 70% are lighter than 10 g. This strongly suggests that if there had been soft hammer flakes originally on the surface of the gravel, many of these would have been quickly winnowed away through fluvial action.

Another morphological difference between hard and soft hammer flakes which might have an effect on taphonomy, is relative thickness. More lenticular flakes are more likely to be picked up through fluvial action. Figure 22b shows the difference in thickness between the rolled hard hammer flakes, the fresh hard hammer flakes, and the fresh soft hammer flakes. The distributions for both sets of hard hammer flakes are quite similar, but both showed a marked difference with the soft hammer flakes, which are markedly thinner.

The combination of weight and thickness is shown in Figure 22c. Here it is clear that the rolled hard hammer flake group is seriously depleted in thin, light flakes compared to the fresh hard hammer flake group. In the first category (0–10) over 80% of the flakes would appear to be missing, yet it is this category that contributes 60% of the soft hammer debitage.

By themselves these measures do not prove that soft hammer debitage has been winnowed from the gravel, but they do show that the morphological characteristics of soft hammer debitage would make them prone to such action. In combination with the fact that there are twelve rolled soft hammer flakes, and also that the only two bifaces from the area are from the gravel and in a rolled and slightly rolled state (Table 15), then winnowing by fluvial action would seem to be a very plausible explanation for the virtual absence of biface manufacturing debitage in a rolled condition.

Area III, black clay

During excavation it was clear that the artefacts from the black clay were certainly in primary context, if not *in situ*; all the artefacts were found within a 10 cm horizon, and with very few exceptions were lying flat, on or within the black clay (Fig. 14). Refits were also encountered during excavation and many more have been discovered since. Therefore the main question is to what degree have the artefacts moved horizontally? The interpretation of the black clay as a palaeosol implies a stable environment, but there are still potential ways in which the artefacts could have moved. The black clay seems to be a soil that developed on a fluvial sediment (see above). Therefore, the artefacts were deposited in the uppermost part of this sediment, prior to full soil development. This implies that the artefacts could have been disturbed by a range of processes from fluvial movement, disturbance by colluviation, bioturbation, to simply trampling by humans or other mammals.

The condition of the artefacts is very uniform, the vast majority being fresh or very slightly abraded (Fig. 23) and with virtually no scratching. As with other areas, the degree of patination and staining varies. The fresh condition certainly suggests a primary context. The slight abrasion on some artefacts could have been caused by slight movement, and the breaks by trampling.

The size distribution of the artefacts (Fig. 21) also tends to suggest little disturbance, although there seems to be a lower percentage of chips compared to the assemblage from the 'brickearth' in Area I and that of Schick (1986). This probably implies that some

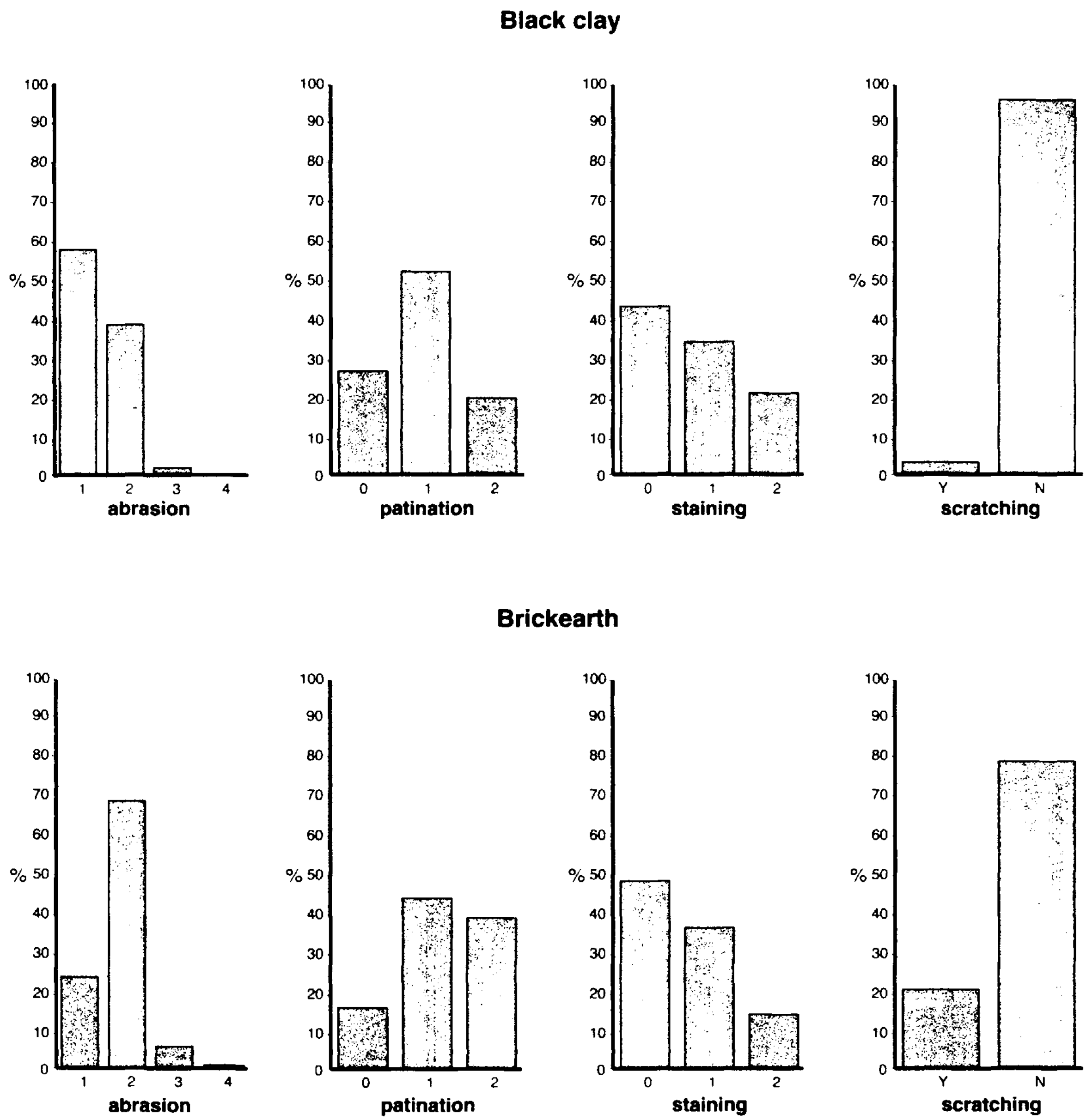


Fig 23.
Percentages of abrasion, patination, staining and scratching on the artefacts from the black clay and 'brickearth' in Area III. Key: *abrasion:* 1 = unabraded; 2 = slightly abraded; 3 = moderately abraded; 4 = very abraded. *Patination:* 0 = unpatinated; 1 = patinated; 2 = very patinated. *Staining:* 0 = unstained; 1 = stained; 2 = very stained. *Scratching:* Y = scratched; N = unscratched.

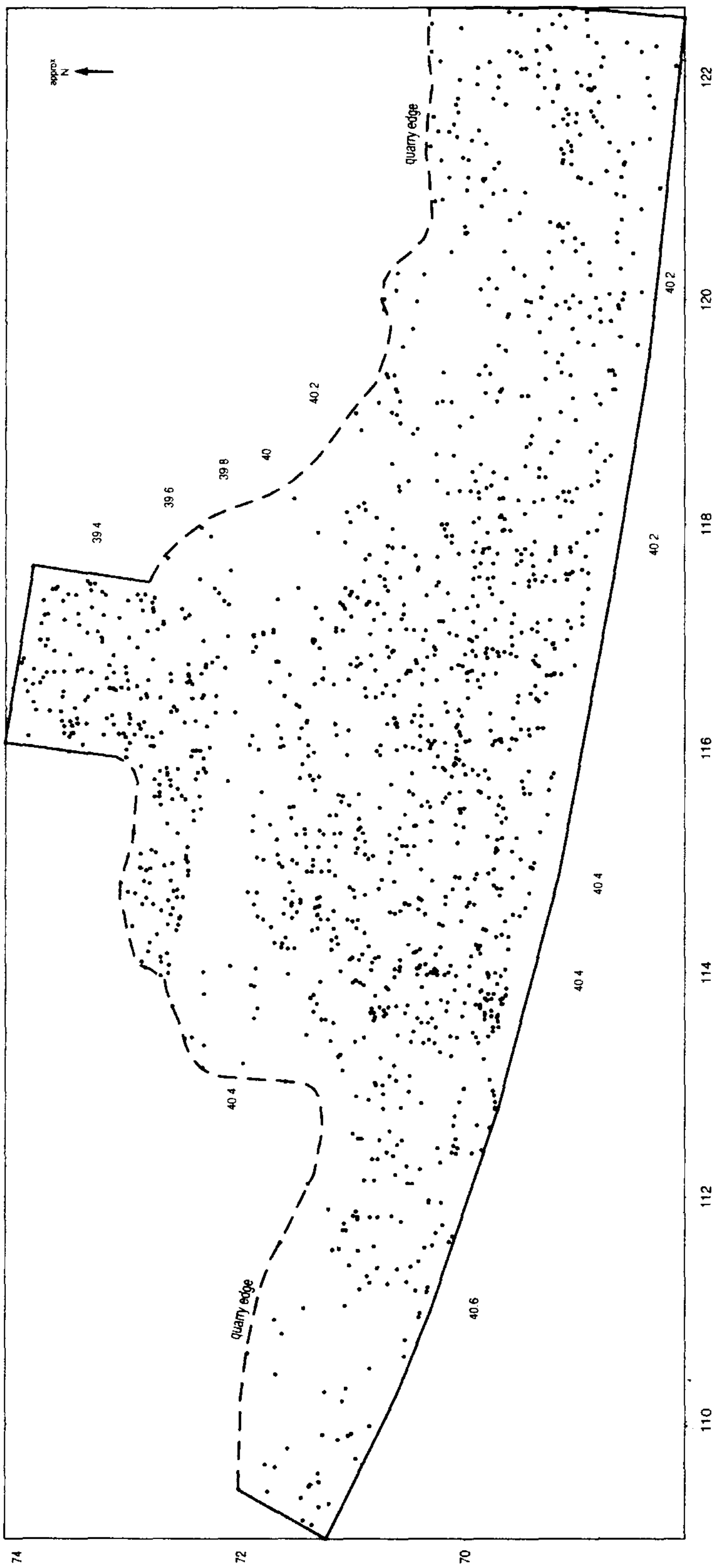


Fig 24.
Distribution of artefacts in Area III from the black clay.

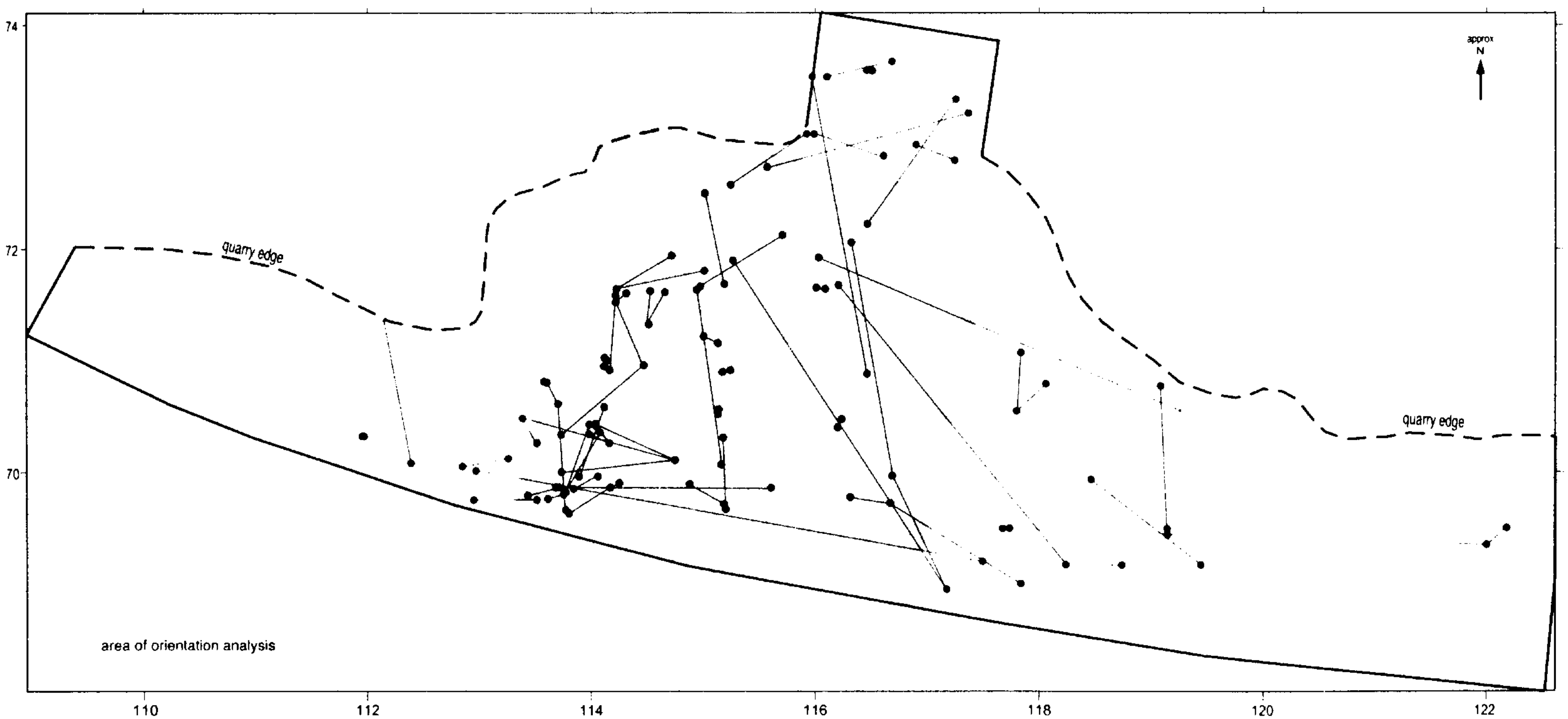


Fig 25.
Refitting artefacts in Area III from the black clay. Orientation of refits was measured initially on the complete assemblage (Fig. 26a) and then from the shaded area (Fig. 26b).

of the chips have been winnowed away from the surface of Area III.

The spatial distribution of the artefacts is of little help in understanding any potential disturbance (Fig. 24); there are no distinct scatters, apart from a higher density in the central part of the trench, and a lower density at the point of increased slope. The refits provide better evidence (Fig. 25). Of the 44 individual groups, there are 60 refit links. Refits of a short distance (<25 cm) were not used leaving a total of 44 links. The orientation of the refits has been plotted by adding the distances between the refits that are orientated within 30° brackets. This shows a preferred orientation on an east–west axis (Fig. 26a). However, this might well be due to the elongation of the trench in the same axis.

To test this, a 4 x 4 m square was taken within the area, incorporating over 50% of the refits (Fig. 25). Only those refits that lay within the square were plotted, thus avoiding any bias introduced by the shape of the trench (Fig. 26b). This shows a totally different orientation, on a roughly north–south axis. As the surface dips slightly towards the north, this would suggest that artefacts were being moved, probably naturally, towards the river edge. The inference must be that some artefacts have moved very slightly, either by fluvial movement down-slope, or by other slope processes. With this background disturbance it is very difficult to recognise any movement of artefacts that might be anthropogenic.

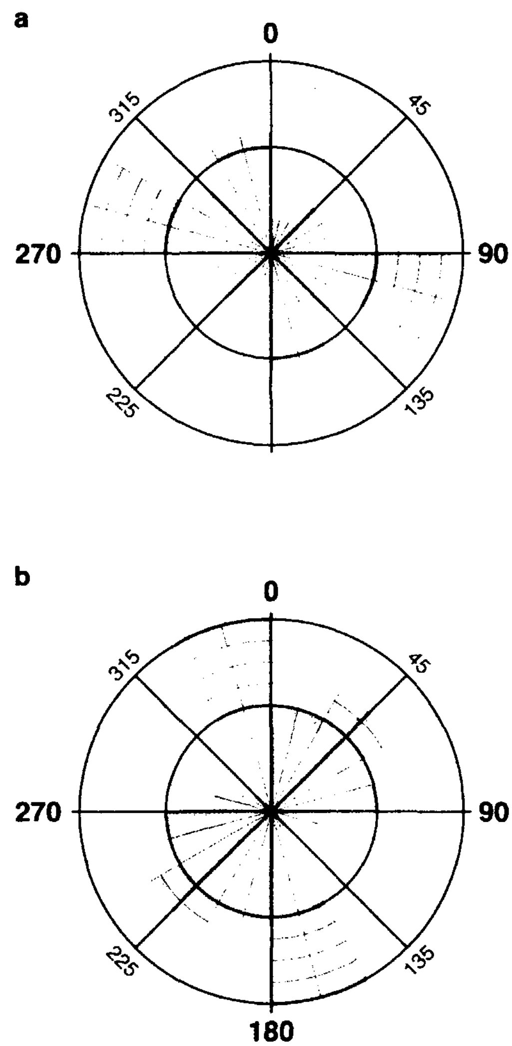


Fig 26.
Orientation of refits in Area III from the black clay. Orientation was divided into 30° sectors and given a linear weighting by refit distance. a. shows the complete assemblage. b. shows refits from the shaded area in Fig. 25, to avoid the bias provided by the trench orientation.

Area III, 'brickearth'

The 229 artefacts from the 'brickearth' formed a thin distribution within c. 1m of sediment above the black clay (Fig. 13). Controlled, but rapid, excavation of this unit undoubtedly led to some loss of recovery, so size distribution is not used in the analysis. The main question to be addressed is whether this material is in primary context or actually derived from the black clay below. The sediment is very similar to the 'brickearth' of Area I, which was interpreted as a largely colluvial deposit, with hints of poorly-developed palaeosols within it. In addition, thin sand lenses suggested occasional fluvial activity. As such, some disturbance of the artefacts within this sediment unit would be expected.

The dominant condition of the artefacts is slightly abraded with a low proportion of scratching, showing slightly more damage than the assemblage from the black clay (Fig. 23). The range of staining of the pieces is generally similar to those from the black clay, although they are slightly more patinated. Overall the condition of the artefacts is not inconsistent with them being derived from the black clay, with the slight increase in abrasion and scratching caused by movement in the 'brickearth'. Compared to the artefacts from the 'brickearth' in Area I, those from Area III 'brickearth' are fresher, and less scratched, patinated, and stained. If the interpretation is correct that both assemblages consist of derived material, the differences above suggest that they are derived from different sources.

The thin distribution of the artefacts throughout the 'brickearth' suggests that the material has been moved. There were no distinct clusters of material suggestive of knapping scatters, nor have refits been found which again suggests some disturbance.

Whether or not the artefacts from the 'brickearth' were derived from the black clay is difficult to assess, although it seems unlikely that they are in primary context.

Areas II and IV

The artefacts from both Areas II and IV were recovered from similar gravels to those described for Area I. They display a similar range of conditions and were probably subject to the same post-depositional processes. In Area II there has been additional disturbance, with the slumping of the deposits into a solution hollow (see above).

Area V

Area V is important as it provides the stratigraphic links between Areas I and III (see above). Within this area it can be seen that the gravel of Area I thickens to the south-east to form a more complex series of sand and gravel units. These seem to form a lobe at the edge of the channel, but that thins and fades out towards Area III. The black clay of Area III can be clearly seen overlying these sand and gravel units, and can be traced in a more poorly developed form immediately above the gravel of Area I (Fig. 9). The artefacts from this area can therefore be divided between those that were found on or in the black clay, and those that were found in the sand and gravel units.

The 146 artefacts from the black clay probably have a similar taphonomic history to those from the black clay in Area III, suggesting that the assemblage is at least in primary context, if not *in situ*. However, there is a comparatively high percentage of abraded and scratched artefacts (Table 9) suggesting slightly greater disturbance, perhaps similar to the artefacts associated with the much more poorly-developed black clay in Area I.

The 93 artefacts from the sand and gravel are likely to have moved post-depositionally, and subjected to the same range of processes as the gravel in Area I. Of significance is the relatively high proportion of soft hammer debitage compared to the gravel of Area I (Table 7). The finer-grained context might explain these differences and might also suggest that there has been less winnowing of the smaller element in this area.

Taphonomic indicators: summary

The taphonomy has helped to identify three main assemblages that can be studied from a technological

TABLE 9: CONDITION OF FLAKES BY PERCENTAGE FOR AREAS I – V

	Area I		*Area II*	*Area III*		*Area IV*	*Area V*	
	Gravel (n=249)	*Brickearth (n=515)*	*Gravel (n=71)*	*Black clay (n=656)*	*Brickearth (n=169)*	*Gravel (n=124)*	*Black clay (n=40)*	*Gravel (n=54)*
Unabraded	14	31	3	59	24	5	17.5	9
Slightly abraded	32	51	61	39	69	64	55	59
Moderately abraded	43	15	32	3	6	27	25	26
Very abraded	11	3	4	0	1	4	2.5	6
scratched	61	36	30	3	35	60	42.5	41
unscratched	39	64	70	97	65	41	57.5	59
Unpatinated	24	9	10	27	17	10	35	13
Slightly patinated	39	9	7	53	44	40	45	67
Patinated	37	82	83	20	39	50	20	20
Unstained	29	32	48	44	49	21	47.5	56
Slightly stained	27	48	37	35	37	52	20	26
Stained	44	20	15	21	14	27	32.5	19

and typological perspective. Two of these consist of the rolled and fresh assemblages from Area I, which provide insights into earlier and later activity at the site. The third is the largely undisturbed assemblage from the black clay in Area III.

RAW MATERIAL STUDIES

Most if not all the flint raw material at Elveden seems to have been local, but was available in two different forms. The most obvious and probably abundant was the lag gravel in Areas I, II, IV, and V. This consists of small to medium pebbles (usually less than 10 cm maximum dimension) but with occasional larger cobbles. The origin of this raw material is probably mixed, some having been derived from nearby Chalk, while other material has clearly had a long history of derivation, obvious from its battering. That at least some of the material was derived from glacial outwash is clear by the occasional presence of blocks of white, banded Lincolnshire flint. The lag gravel flint is very variable in condition, but frequently the cobbles show signs of thermal fractures and other flaws in the flint.

The second raw material is rarer, but consists of often large (> 25 cm maximum dimension) nodules of flint that have been derived from the Chalk in the immediate area of the site. They are most obvious as occasional clasts in the 'brickearth', but probably also contribute to a small extent to the lag gravel. They are very fresh in condition, although knapping experiments have shown that they often still contain natural flaws.

The varying use of the two different sources can be assessed by the condition of the cortex. This technique was first used by White (1998a) who distinguished between an often thick, fresh, chalky texture to the cortex, and a thinner, smoother, sometimes pitted appearance. This he used to assess the variation in raw material use for biface manufacture on British sites.

The same analysis was undertaken on the raw material at Elveden for the three main assemblages (Table 10). Three categories were identified: 1 – unworn cortex; 2 – intermediate; and 3 – worn cortex. Additionally, the Area I fresh assemblage and the Area III black clay assemblage were split into hard and soft hammer elements to look for differences in raw material use with different technologies. The rolled assemblage from Area I contained too little soft hammer debitage to make a division statistically valid, so only the hard hammer flakes were examined.

The initial analysis shows that unworn material was preferred in all the assemblages, with category 1 (unworn) accounting for over 54% in the rolled assemblage and over 68% in all other cases. Of note are the higher percentages for this category for the soft hammer assemblages, particularly that from the black clay in Area III. It seems that unworn material was selected in particular for biface manufacture.

TABLE 10: PERCENTAGES, MEAN WEIGHTS, AND CORTICAL INDICES FOR UNWORN (1), MODERATELY WORN (2) AND WORN (3) CORTEX TYPES FOR AREAS I AND III. HH = HARD HAMMER; SH = SOFT HAMMER

Raw material type	*Area I fresh HH flakes (n=183)*	*Area I rolled HH flakes (n=126)*	*Area III black clay HH flakes (n=175)*	*Area I fresh SH flakes (n=53)*	*Area III black clay SH flakes (n=66)*
1	68	54	71	75	86
2	17	23	25	19	8
3	15	23	4	6	6
	mean wt (g)				
1	40	95	71		
2	58	97	72		
3	43	56	43		
	cortical index				
1	56	55	57		
2	64	66	59		
3	67	63	86		

The comparatively low percentage for the rolled assemblage could possibly be accounted for by the difficulty of distinguishing between pre-knapping and post-depositional wear to the cortex; criticisms of the method have been put forward on this basis by Wenban-Smith *et al.* (2000, 247). To test whether this is really a problem, the weights of the flakes in each assemblage can be compared. The worn cobbles in the lag gravel are generally smaller than the fresh cobbles on the lag gravel and in the 'brickearth' above. Therefore the debitage sizes should be smaller on worn material. If worn cortex is being misidentified, and is actually due to post-depositional processes, then this pattern would not hold true. Table 10 shows that in the rolled assemblage the weights for worn cortex flakes are considerably lighter than unworn cortex flakes. This suggests that distinguishing between pre-knapping wear and post-depositional wear is not a problem. This same pattern is seen with the black clay hard hammer assemblage, although this pattern is not clear with the fresh hard hammer assemblage from Area I. The soft hammer assemblages are too small to assess in this way.

A further indication is given by the amount of cortex on the flakes; artefacts with unworn cortex generally have less cortex than those with a worn cortex, suggesting that the latter come from smaller nodules.

The most noticeable pattern, therefore in terms of technology, is the overall preference for the larger, freshly derived raw material. This preference might increase through time, as the pattern is less noticeable with the older, rolled assemblage, perhaps reflecting the increasing availability of the fresher, unworn raw material over time. Finally, fresher raw material seems to have been particularly selected for biface manufacture. This might partly reflect the decrease in availability of the gravel as the channel dried up and soils developed over the area.

Core and flake technology

The system used to understand the core and flake technology is similar to that that used in the Swanscombe and Barnham reports (Ashton & McNabb 1996; Ashton 1998b). The system is based on the recognition of one or more sequences of removals on a core. These sequences or core episodes can be described as; single removal (type A) where one flake is removed in isolation; parallel flaking (type B) where two or more flakes are removed from the same or adjacent platforms; alternate flaking (type C) where following on from type A or B the core is turned and the proximal ends of the flake scar or scars act as the platform for one or more further removals. The sequence can develop further by the core being turned back to the original direction with further removals; type D describes the situation where remnants of previous flaking can be recognised, but cannot be related to specific core episodes. The method of recording the flakes provides support for the interpretation of the cores. Of particular importance are the butt types, the dorsal scar patterns and the amount of cortex. The measures used in Tables 12 and 14 are explained in Appendix I.

THE CORES

The cores (Fig. 29) have been analysed using the method described above and in addition weight, size, and cortex retention have also been considered. The number of cores from the fresh assemblage in Area I is too small (six cores) for any meaningful analysis, so it has been combined with the rolled assemblage from that area. As with most Lower Palaeolithic sites, the predominant technique was alternate flaking (type C) with some parallel flaking (type B) and a high proportion of flakes removed singly (type A). Equally the three ratios of flakes, core episodes and cores are very similar between the assemblages, suggesting few differences in technology, although the slightly higher ratios from Area III might hint at more intensive working (Table 11).

One puzzling element of the cores is the major difference in their size and weights, with those from Area I being on average considerably smaller. The interpretation of the assemblage from the 'brickearth' as material that has been derived by slope-processes from a higher exposure of the gravel, might explain why some larger elements were left behind. However, this does not explain the cores from the lag gravel, where larger cores would be expected to survive. Also puzzling are the comparatively high hard hammer flake to core ratios for the fresh assemblage in Area I, compared to Area III, suggesting a core deficit in the former assemblage. This pattern is difficult to explain by taphonomic processes and other explanations should be sought. One of the characteristics of both assemblages is the number of cores that have single flakes removed in isolation (type A core episode). This suggests that much of the knapping was testing nodules. Indeed when this does occur it is frequently on nodules that have internal flaws and seem to be quickly abandoned. If Area I was primarily a location

TABLE 11: CORE MEASUREMENTS, EPISODE TYPES AND RATIOS FOR AREAS I AND III FROM ELVEDEN AND AND AREAS I AND IV (4) FROM BARNHAM. SEE APPENDIX I

	Area I fresh (n=6)	*Area I rolled (n=15)*	*Area I rolled (n=21)*	*Area III (n=22)*	*Barnham I (n=85)*	*Barnham IV(4) (n=31)*
mean & sd						
Length	83 ± 29	93 ± 29	90 ± 28	120 ± 34	97 ± 38	115 ± 36
breadth	59 ± 22	67 ± 17	65 ± 18	98 ± 32	79 ± 30	91 ± 23
thickness	40 ± 21	47 ± 14	45 ± 16	68 ± 31	57 ± 28	62 ± 18
weight	246 ± 327	326 ± 265	303 ± 278	861 ± 747	599 ± 1003	638 ± 716
% core episodes						
A - single removal	10	50	38	36	22	20
B - parallel flaking	20	9	13	17	14	14
C - alternate flaking	60	41	47	44	54	61
D - early misc. flaking	10	0	3	3	10	5
Ratios						
Flake scars/core	4.8	4.1	4.3	5.2	7.6	5.6
Flake scars/episodes	2.9	2.8	2.8	3.2	4	3.9
episodes/core	1.7	1.5	1.5	1.6	1.9	1.4
cortical index	38	67	54	53		
ratio HH flakes: cores (fresh groups only)	63.2			16.9	16.3	9.5

for nodule selection and initial flaking, with the larger, more successful nodules taken away for both core and flake working and biface manufacture, then this is the sort of patterning that might be expected. It is equally plausible that some of the partially-knapped nodules would be taken to a dry location such as Area III. Almost certainly the human behaviour was not this simple, but it seems reasonable to suggest that Area I saw the net export and Area III the net import of nodules and cores.

Comparisons can be drawn with the core technology from Barnham. Although the overall technology is similar, slight differences are apparent. Both areas at Barnham indicate more use of alternate flaking (type C) and less use of single removal (type A). This suggests more intensive flaking of the cores, which is supported by the higher ratios for flake scars: core and flake scars: core episode. Otherwise the sizes and weights of the cores and the ratio of hard hammer flakes to cores is similar to Area III at Elveden.

THE HARD HAMMER FLAKES

The analysis of the hard hammer flakes supports the conclusions from the cores. Typically the flakes are dominated by mainly plain, but also cortical or natural butts, the cortical indices show the usual range from fully

Fig 27.
Refitting core and flakes (P1997.3-1.288-295) from Area III.

TABLE 12: ATTRIBUTES FOR HARD HAMMER FLAKES BY PERCENTAGE FOR ELVEDEN AREAS I AND III, BARNHAM AREAS I AND IV (4) AND EXPERIMENTAL SET. RCE = RELICT CORE EDGE; DSP = DORSAL SCAR PATTERN. SEE APPENDIX 1 FOR FULL KEY

	Area I fresh	*Area I rolled*	*Area III black clay*	*Barnham I fresh*	*Barnham IV (4) fresh*	*Experimental*
Butt	*n=261*	*n=161*	*n=204*	*n=349*	*n=69*	*n=79s*
1 - plain	66	67	50	75	70	65
2 - dihedral	8	6	13	7	3	6
3 - natural	19	21	26	14	20	24
4 - marginal	5	2	10	2	7	4
5 - mixed	2	4	1	1	0	1
Cone	*n=261*	*n=161*	*n=204*			
Y	54	58	41			
N	46	42	59			
Break	*n=379*	*n=214*	*n=382*	*n=475*	*n=123*	*n=106*
Y	57	51	69	46	62	57
N	43	49	31	54	38	43
Adjustment	*n=379*	*n=214*	*n=382*	*n=475*	*n=123*	*n=106*
Y	5	2	15	10	6	18
N	95	98	85	90	94	82
Cortex	*n=379*	*n=214*	*n=382*	*n=475*	*n=123*	*n=106*
100%	17	15	14	9	18	16
>50%	19	25	19	19	19	24
<50%	39	37	43	41	39	46
0%	25	23	24	30	23	14
Cortic. index	43	44	41	35	44	47
RCE	*n=98*	*n=46*	*n=59*	*n=121*	*n=19*	*n=54*
1	2	9	10	7	5	11
2	0	2	3	3	5	0
3	0	0	2	2	0	0
4	95	89	78	75	84	87
5	2	0	3	8	5	0
6	1	0	3	5	0	2
DSP	*n=98*	*n=46*	*n=59*	*n=121*	*n=19*	*n=54*
1	37	39	45	50	47	37
2	23	19	19	13	8	20
3	2	3	2	1	0	1
4	4	2	2	1	2	0
5	11	14	10	15	7	16
6	1	1	2	1	1	0
7	3	2	3	1	2	3
8	1	1	0	2	2	1
9	1	0	0	0	0	1
10	17	15	15	15	29	18
11	0	0	0	1	1	1
12	0	3	1	1	2	3
Distal index	9	8	8	4	7	7

continued on p. 42

	Area I fresh	*Area I rolled*	*Area III black clay*	*Barnham I fresh*	*Barnham IV (4) fresh*	*Experimental*
Dorsal scars	*n*=98	*n*=46	*n*=59			
0	17	15	15			
1	19	23	26			
2	24	28	27			
3	28	23	21			
4	9	7	5			
5	3	2	5			
6	1	0	1			
Scar index	**21**	**19**	**19**			
mean & sd						
Butt thickness	9 ± 7	12 ± 7	8 ± 7			
Length	43 ± 21	55 ± 23	45 ± 25	49 ± 31	52 ± 27	48 ± 22
Breadth	39 ± 17	49 ± 20	40 ± 22	41 ± 21	47 ± 24	43 ± 23
Thickness	13 ± 8	18 ± 10	13 ± 11	15 ± 10	16 ± 10	13 ± 8
Weight	31 ± 55	70 ± 86	42 ± 87	48 ± 106	61 ± 101	37 ± 57

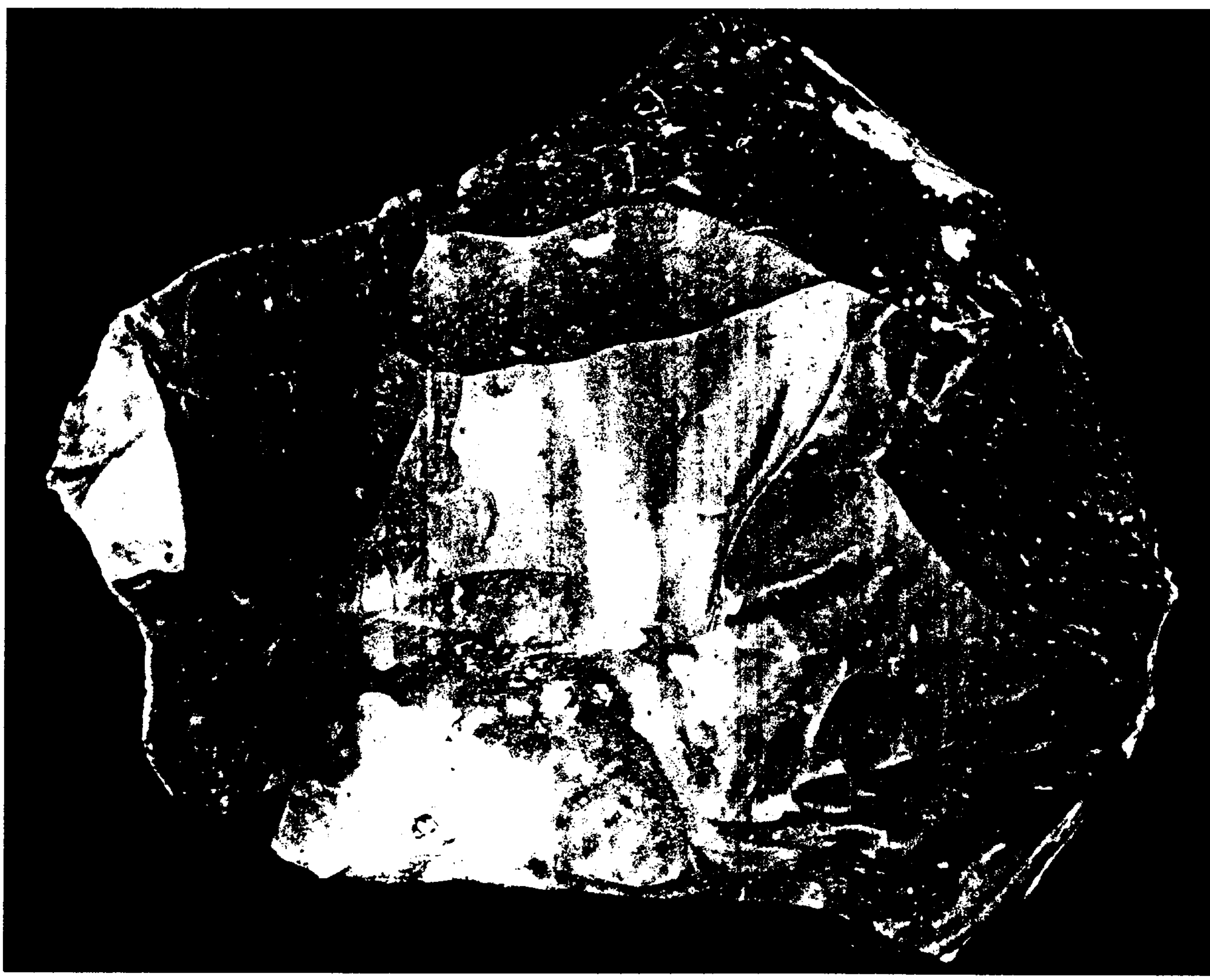


Fig 28.
Refitting biface roughout and flake, Group A (P1997.3-1.2 and 3).

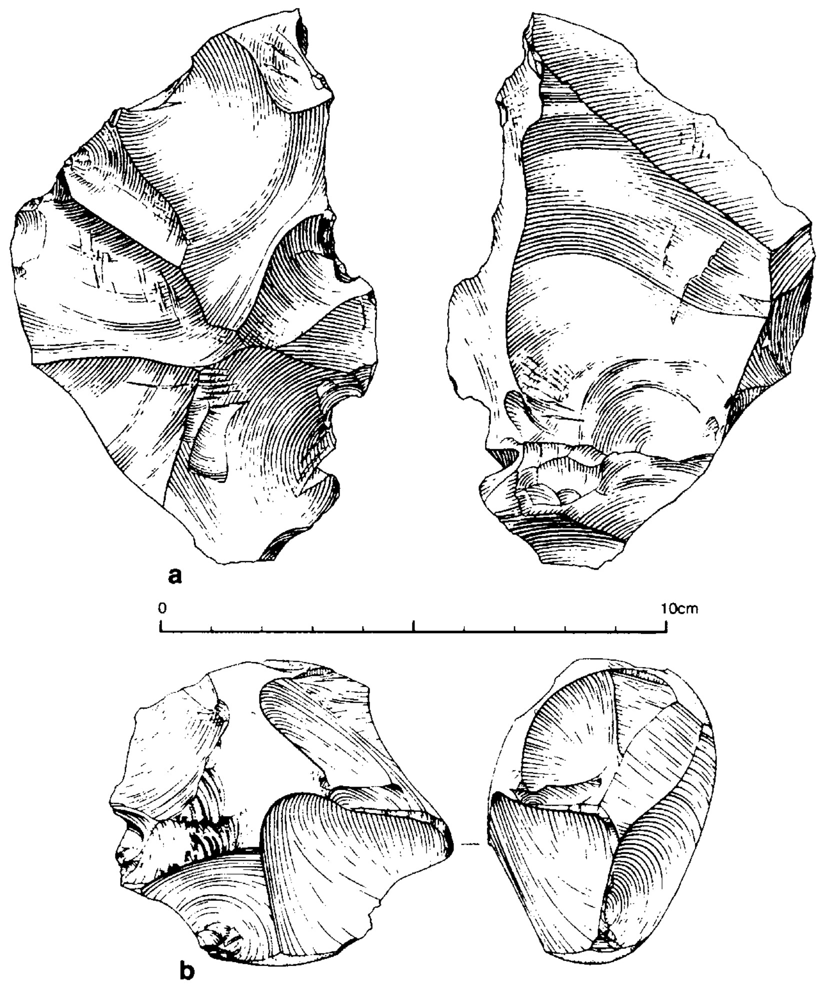


Fig 29.
a. 1997.3-1.695. core from Area III black clay showing initial flaking on one face, followed by more extensive flaking on the opposite face; b.1997.3-1.689. core from Area III black clay showing two episodes of alternate flaking.

cortical flakes to those lacking cortex and the relict core edges are dominated by type 4, which is indicative of sequences of knapping from the same platform. The dorsal scar patterns show little knapping from the distal end, and the scar counts are similar for all three assemblages. What is particularly notable is the technological similarity between the rolled and fresh assemblages from Area I. Despite obvious taphonomic differences, reflected in size, this has not affected the technological measures, suggesting that technologically they can be regarded as a single population.

Slight differences might be noted between the Area I assemblages and Area III. These are the increased number of dihedral and marginal butts, the decrease in cones or 'ring cracks' at the point of percussion, the increase in breakage and the increase in platform adjustment. These differences might be explained by the inclusion of some biface manufacturing flakes in the assemblage, due to the difficulties of distinguishing between hard hammer flakes from cores and those produced in the initial stages of biface production. If this were the case then the same phenomenon might be expected in the fresh assemblage from Area I. This does not seem to be the case, although with the Area I fresh assemblage biface manufacture was relatively less important than core and flake production, and therefore misidentification of initial biface manufacturing flakes would have less effect on the hard hammer figures for that area.

The comparison with the assemblages from Barnham and the experiments undertaken at that site (Ashton 1998b) show remarkably similar results to those from Elveden. The suggestion that the cores indicate more intensive flaking at Barnham is neither supported nor negated by the evidence from the flakes.

REFITTING GROUPS

Of the 28 refitting groups of hard hammer debitage from the two areas, only one is from Area I. Of the remainder from Area III, thirteen are old breaks and fourteen are technological refits. Only one of the technological refits contains more than three artefacts and this is described below (Fig. 27)

A nodule, approximately 19 x 17 x 16 cm in size was knapped using three core episodes. Two flakes were removed independently of other flakes and of each other on one part of the nodule (both Type A core episodes). The third core episode was one long sequence of alternate flaking technique. This consisted of a large single flake (missing) being removed in direction A, followed by at least 11 removals in direction B, of which at least four are missing. The sequence is therefore: Direction A: 1 flake missing; Direction B: P1997.3-1.293, 2 flakes missing, P1997.3-1.295, 2 flakes missing, P1997.3-1.294, 290, 288, 289, 291/292. This type of flaking seems to be typical of the core-working described for the remainder of the assemblage.

Flake tools

The number of flake tools from the site is very small, there being a total of only thirteen from all the areas (Fig. 30). Because the numbers are so few, they are all described in Table 13. Other than the rarity of flake tools, there are very few

TABLE 13: FLAKE TOOLS FROM ELVEDEN

Assemblage	*Figure*	*Description*
Area I fresh assemblage		*1995.1-2.375*. Scraper. The distal part of small flake with very limited retouch at the distal end
Area I fresh assemblage	30.b	*1995.1-2.405*. Scraper. A naturally fractured thin block with invasive and slightly stepped retouch creating one straight edge. the piece has been subsequently flaked from a break across the top of the piece and truncating the retouch
Area I fresh assemblage	30.e	*1995.1-2.473*. Notch. A flake with a large Clactonian notch on the distal end
Area I fresh assemblage	30.c	*1995.1-2.673*. Scraper. A large flake with some ventral flaking that has removed the butt and the distal end. There is subsequent flaking on the proximal, right lateral and distal ends to form a convex, retouched edge
Area I rolled assemblage		*1995.1-2.616*. Notch. A rolled flake with an unrolled retouched notch on the left lateral edge
Area I rolled assemblage		1995.1-2.653. Scraper. A flake with a broken distal end and with retouch on the left lateral edge
Area III brickearth	30.g	*1997.3-1.821*. Scraper. A large broken flake with steep, stepped, inverse retouch on the distal end to create a concave edge
Area III black clay	30.f	*1997.3-1.281*. Scraper. A shattered fragment of a flake with slightly concave retouch on one edge
Area III black clay		*1997.3-1.282*. Notch. A flake broken by siret fracture with a Clactonian notch on each of the lateral edges, and subsequent retouch on the ridge formed by the intersection of the two notch removals
Area III black clay		*1997.3-1.283*. Notch. Adjacent Clactonian notches opposite a further notch, on a piece thinned on the opposite face
Area III black clay		*1997.3-1.284*. Notch. Flake with a retouched notch on the right lateral edge
Area III black clay	30.d	*1997.3-1.286*. Notch. Flake with two adjacent Clactonian notches on the right lateral edge
Area III black clay	30.a	*1997.3-1.687*. Notch. Knapping fragment with retouch on one edge

classic scrapers or notches. In contrast, the blanks that are selected appear to be stray pieces of debitage, frequently on knapping fragments, very rarely on large flakes, and in one case on naturally-fractured flint. This appears to reflect an *ad-hoc* behaviour, where blanks are selected within a hand's reach, rather than several paces away. Equally, the type of retouch is very variable, with apparently little effort given to providing consistency or uniformity.

Biface technology

The soft hammer flakes from Area I (fresh assemblage) and Area III (black clay) have been

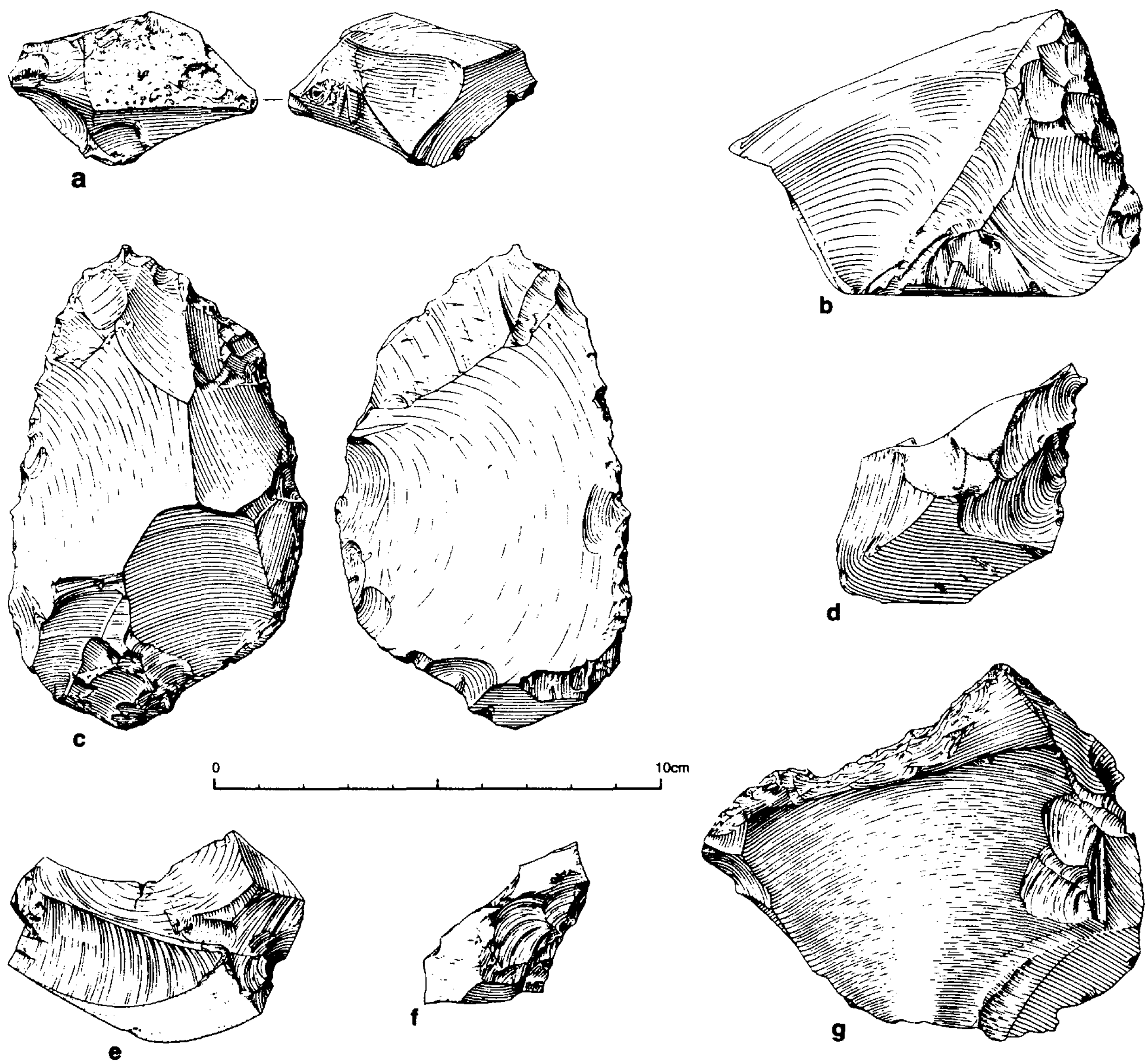


Fig 30.
a. 1997.3-1.687. retouched knapping fragment from Area III black clay; b. 1995.1-2.405. scraper from Area I fresh assemblage; c. 1995.1-2.673. retouched flake with bifacial flaking from Area I fresh assemblage; d. 1997.3-1.286. Clactonian notch from Area III black clay; e. 1995.1-2.473. Clactonian notch from Area I fresh assemblage; f. 1997.3-1.281. retouched flake from Area III black clay; g. 1997.3-1.821. scraper from Area III brickearth. (see Table 12)

TABLE 14: ATTRIBUTES FOR SOFT HAMMER FLAKES BY PERCENTAGE FOR ELVEDEN AREAS I AND III, BARNHAM AREAS IV (4) AND V, AND EXPERIMENTAL SET. SEE APPENDIX I FOR KEY

	Area I fresh	*Area III Black Clay*	*Barnham IV (4)*	*Barnham V*	*Experimental*
Butt	*n=81*	*n=100*	*n=136*	*n=13*	*n=114*
1 – plain	47	49	40	46	52
2 – dihedral	16	12	11	8	6
3 – natural	15	8	14	0	3
4 – marginal	21	29	33	46	39
5 – mixed	1	2	2	0	0
Cone	*n=81*	*n=100*	*n=136*	*n=13*	*n=114*
Y	25	20	16	15	45
N	75	80	84	85	55
Break	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
Y	84	92	85	86	77
N	16	8	15	13	23
Adjustment	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
Y	26	52	46	38	61
N	74	48	54	62	39
Cortex	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
100%	7	2	4	2	1
>50%	7	7	9	4	8
<50%	39	28	41	17	40
0%	47	62	46	77	51
Cortic. index	**25**	**16**	**24**	**10**	**19**
Dorsal scar pattern	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
1	42	60	57	58	49
2	30	23	17	19	26
3	4	3	3	4	4
4	6	1	3	2	4
5	4	6	5	10	4
6	1	0	2	0	0
7	5	4	4	4	6
8	0	1	1	0	1
9	1	0	1	0	1
10	7	1	5	2	1
11	0	0	0	0	1
12	1	1	1	0	1
Distal index	**14**	**6**	**11**	**6**	**12**

continued on p. 47

Area I fresh	*Area III*	*Barnham Black Clay*	*Barnham IV (4)*	*Experimental V*	
Dorsal scar	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
0	7	1	6	2	1
1	14	20	22	23	5
2	24	29	28	29	35
3	31	31	18	31	35
4	12	11	13	11	19
5	6	4	8	4	4
6	4	3	3	0	1
7	2	0	1	0	1
8	0	1	1	0	0
9	0	0	1	0	0
Scar index	**27**	**26**	**26**	**24**	**29**
mean & sd	*n=159*	*n=274*	*n=268*	*n=52*	*n=176*
Butt thickness	4 ± 3	4 ± 5	5 ± 4	6 ± 3	3 ± 2
Length	39 ± 16	36 ± 18	47 ± 27	36 ± 14	39 ± 15
Breadth	33 ± 13	33 ± 16	41 ± 20	33 ± 11	34 ± 12
Thickness	6 ± 3	7 ± 5	9 ± 6	6 ± 3	5 ± 3
Weight	10 ± 15	12 ± 25	22 ± 36	7 ± 7	6 ± 7
Weight range	1 - 116	1 - 168			

analysed by a similar set of methods to those used on the hard hammer flakes (Table 14). The differences in technology between the soft and hard hammer flakes are clear, in particular the increase in breakage, platform adjustment, the scar index, and in marginal butts (type 4), together with a decrease in the number of cones and in the cortical index. Finally there is a marked reduction in size. These differences tend to support the division of the flakes into hard and soft hammer, although this is never a finite art, and there may be some that have been misidentified.

There are several differences between the two assemblages that might be technologically significant. The Area III assemblage has higher figures for marginal butts, breakage, and platform adjustment, but lower figures for cortical butts, the cortical index, and the distal index. Collectively these figures hint at a higher proportion of later stage knapping being represented in the Area III location. This surprisingly includes the lower distal index, where figures from the experiments at Barnham (Wenban-Smith & Ashton 1998) showed a decrease in the number of distal scars as knapping proceeded, this being primarily due to the average decrease in length of flake in the later stages of biface manufacture.

Some support for this interpretation comes from the two biface assemblages at Barnham. Area IV(4) was interpreted as including all stages of manufacture, whereas Area V was argued to contain only the later stages. Unfortunately butt features only survived on thirteen of the Area V flakes and should therefore be ignored, but two of the other statistics (on the whole assemblage of 52) show a pattern. These are the lower cortical and distal indices for Area V, compared to Area IV(4).

If the interpretation for Elveden is correct, then it suggests that at least some nodules were brought into Area III partially knapped, perhaps as roughouts. This interpretation is supported by several other lines of evidence:

1. the presence of only one biface roughout in Area I, but of four in Area III;
2. the increase in emphasis on biface manufacture in Area III; and
3. the implication from the core and flake-working that Area III sees the net importation of nodules or partially-worked cores, in contrast to Area I.

One set of statistics that would appear not to support this interpretation is that of the relative sizes and weights. The expectation would be that the Area III assemblage would tend to be smaller and lighter than that from Area I (see differences between Barnham Area IV(4) and V), but they appear to be remarkably similar. One explanation might be the additional import of larger nodules or roughouts from a different source, such as the nearby eroding Chalk.

Technologically the differences would be maintained, but the sizes would show a broader range. This broader range is shown for the weights in Table 14 and is highlighted by the larger standard deviations for both sizes and weights for Area III, supporting the interpretation offered above.

Overall the process of biface manufacture at Elveden seems to be similar to that described for Barnham. Unlike some previous work and experiments that describe a three stage process from roughing-out with a hard hammer, to thinning and then finishing with a soft hammer (eg, Newcomer 1971), Palaeolithic knappers seem to have adopted a simpler approach. The relative amounts of cortex on some soft hammer flakes suggest the adoption of this hammer mode early on in the process. Finding or distinguishing stages in the process is difficult, except where clear spatial differences occur as at Barnham and Boxgrove (Austin 1994). At Barnham three arbitary divisions were made to summarise the process, but used simply as a descriptive tool. These were termed decortication and initial flaking, middle stage flaking, and final flaking. The characteristics for these stages were as follows.

The decortication and initial flakes tend to be larger in size, have a lower proportion of breakage, thicker, simpler butts, more distinct cones on the butts, and less platform preparation. The features that mark them out as being soft hammer flakes are the diffuse bulbs of percussion, lips below the butt, and often an undulating wave pattern towards the distal end of their ventral surface. They also have a higher proportion of dorsal flake scars from the distal end.

Flakes from the middle stage of reduction tend to be smaller in size, have more knapping breaks, and clearer indications of soft hammer use; they have fewer cones on the butt, more platform preparation, a greater number of marginal butts, and usually the curved profile of soft hammer flakes. They also have a lower number of dorsal flake scars from the distal end, probably due to more intensive flaking on a single edge prior to turning. A final characteristic of these flakes is the higher number of flake scars, partly to be expected from largely uncortical flakes, but also from the increased intensity of flaking.

The final stage of manufacture is characterised by flakes that are smaller in size and have more knapping breaks, with again an increase in the features associated with soft hammer working. One exception is the decrease in the number of prepared platforms, perhaps due to the high frequency of marginal butts, where crushing of the edge during the flake removal has obscured any previous preparation. The dorsal scar patterns also show a decrease in the amount of flaking from the distal end, and perhaps due to small size the scar count decreases.

At Elveden flakes from both Areas I and III bear the characteristics of all three stages described above. However, there has been no attempt to divide the flakes into the different categories because in the absence of spatial differentiation, it would often be an arbitrary process. What is important, however, is the presence of largely cortical flakes, similar to those from Barnham, that bear the characteristics of soft hammer debitage. This suggests that at Elveden, also, a soft hammer was used from a very early stage in the process of biface manufacture.

REFITTING

There are seventeen groups of what appears to be soft hammer debitage, all from the Area III black clay. Of these, seven consist of broken flakes, while ten are technological refits, mainly being pairs of refits. However in two cases flakes refit onto what have been interpreted as biface roughouts, and there is a further group of three refitting flakes. The three groups are described below.

GROUP A (P1997.3-1.2 AND 3)

The group consists of a flake and biface roughout (Fig. 28). A nodule of flint with minimum dimensions of 130 x 110 x 75 mm was reduced in thickness by removing three flakes on one side of the nodule that created a platform for the removal of a long series of parallel flakes. The refitting flake was the final removal that created this platform. The removal of the series of flakes (at least eight, and probably several more) from this platform reduced the nodule from 75 mm to less than 35 mm in thickness and created a flattish surface on that face. On the opposite side, the nodule was worked with at least five flake removals from several directions to create a parallel face, although some cortex was retained. The piece was abandoned when it naturally fractured across its long axis. The one flake that refits was probably a hard hammer removal, although the butt is partly broken. Some of the features on the negative scars of the subsequent removals strongly suggest the use of a soft hammer, certainly in the final working.

GROUP B (P1997.3-1.4 AND 5)

The group consists of a flake and possible biface roughout. A nodule of flint has been taken and extensively knapped across one face from opposite directions to create a relatively thin, oval shaped piece that is fully cortical on one face. The refitting flake is hard hammer and is probably the penultimate removal from the worked face. The negative scars also suggest hard hammer flaking. Despite the use of this hammer mode, there seems to have been a clear attempt to shape a face, which is the reason that it has been interpreted as a possible roughout.

GROUP C (P1997.3-1.21, 22, 126 AND 255).

This group comprises three soft hammer flakes (one in two parts) that show flaking across one face of a missing roughout or biface. The first flake (21) is a large partly cortical flake. The second flake (22) is shorter and thicker, and was removed almost at right angles to the first. The final flake (126 and 255) is thinner and removed from midway between the other two flakes. Collectively the three flakes show working of one face of a roughout

TABLE 15: BIFACES AND BIFACE ROUGHOUTS FROM ELVEDEN

Assemblage	*Figure*	*Description*
Area I rolled assemblage – gravel	33.a	*1995.1-2.532.* Biface. Elongated, thick ovate biface with s-twist edges. Cortex is retained on the butt end on one face. Slightly rolled condition.
Area II gravel	33.b	*1996.3-3.1.* Biface. Ovate biface, but with flakes removed from both lateral edges towards the base on one face, to create slightly concave edges at that end, but retaining the overall symmetry. Slightly rolled condition.
Area IV gravel	31.a	*1998.8-4.1.* Biface tip. Bifacially flaked piece with a pointed, plano-convex tip, but with a break coinciding with a natural flaw in the flint. Fresh condition.
Area I rolled assemblage – gravel	31.b	1995.1-2.533. Roughout. Bifacially worked piece, retaining no cortex, but with extensive inclusions and one post-depositional natural fracture. Rolled condition.
Area II gravel		*1996.3-3.2.* Possible roughout. Large cortical flake with removals across the dorsal face that form a platform for more limited flaking on the ventral face. This later flaking removed the butt. The flaking on the dorsal face could b prior to or after the removal of the original flake. There is a break across the distal end. Fresh condition.
Area II gravel		*1996.3-3.3.* Roughout. Large flake, bifacially flaked (some possibly soft hammer) prior to a diagonal break removing all the distal and some of the proximal end. Fresh condition.
Area III black	32	*1997.3-1.1.* Roughout. Naturally fractured nodule with a partial working of the fractured surface, followed by more extensive soft hammer flaking across the opposite face. Broadly cordiform in outline with a coritical butt. Fresh condition.
Area III black clay		*1997.3-1.2.* Roughout. Nodule that has been bifacially reduced with soft hammer debitage, prior to a break across the long axis. Fresh condition.
Area III black clay		*1997.3-1.4.* Roughout. Nodule with some working on the cortical face, prior to hard hammer flaking across the opposite face. Fresh condition.
Area III black clay		*1997.3-1.6.* Roughout. Nodule with some working on the cortical face and more extensive flaking (some soft hammer) across the opposite face prior to a break at one end and a natural fracture down one side. At least one (probably two) hard hammer flakes were removed after the breakage from the cortical face. Fresh condition.
Area IV gravel		1998.8-4.2. Roughout. Bifacially worked piece, probably ith hard hammer flaking, prior to a break. Slightly rolled condition.
Area IV gravel		1998.8-4.3. Roughout. Bifacially worked nodule with some soft hammer flaking across at least one face. A small amount of cortex is retained on the opposite face and there are breaks along one edge. Rolled condition.
Area V black clay		1999.8-3.1. Roughout. Large thick cortical flake, with one removal from the ventral surface, used as a platform for more extensive flaking (possibly soft hammer) across the dorsal face. Cortex is retained along one edge and across part of the face. fresh condition.
Area V sand gravel	34	1999.8-3.47. Roughout. Bifacially worked nodule, with at least some hard-hammer and working, retaining some cortex on one face. There is a break across one end, after at least some of the flaking. fresh condition.

from adjacent platforms. The dorsal scars show at least four previous removals from a similar range of directions, followed by two flakes from an opposed direction. This group illustrates well the use of a soft hammer for the removal of large flakes at an early stage of biface manufacture.

The bifaces and biface roughouts

Other than the two roughouts described above, there are also three bifaces and nine other roughouts. They are all described in Table 15. There are several points

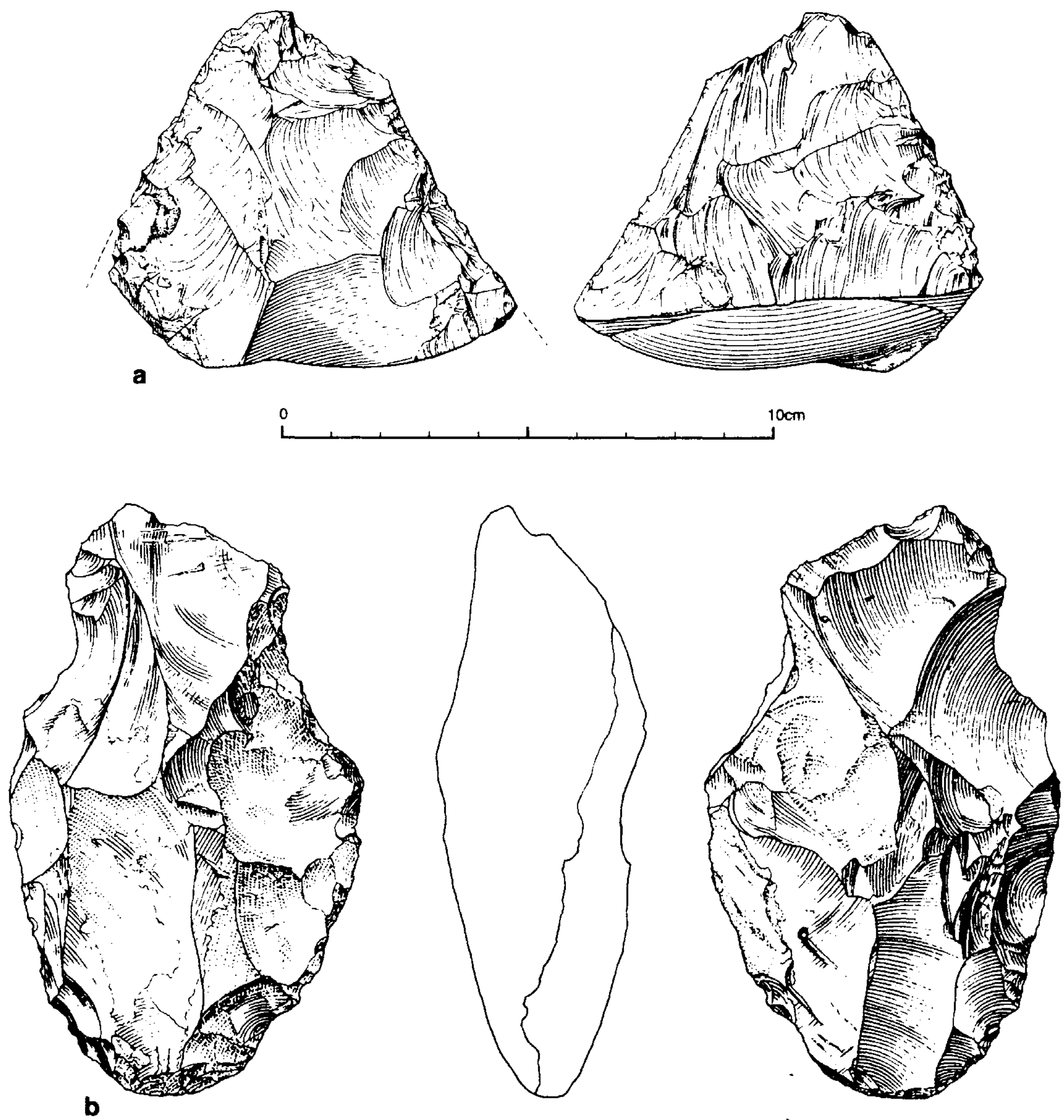


Fig 31.
a. 1998.8-4.1. biface tip from Area IV gravel; b. 1995.1-2.533. biface roughout from Area I rolled assemblage. (see Table 15).

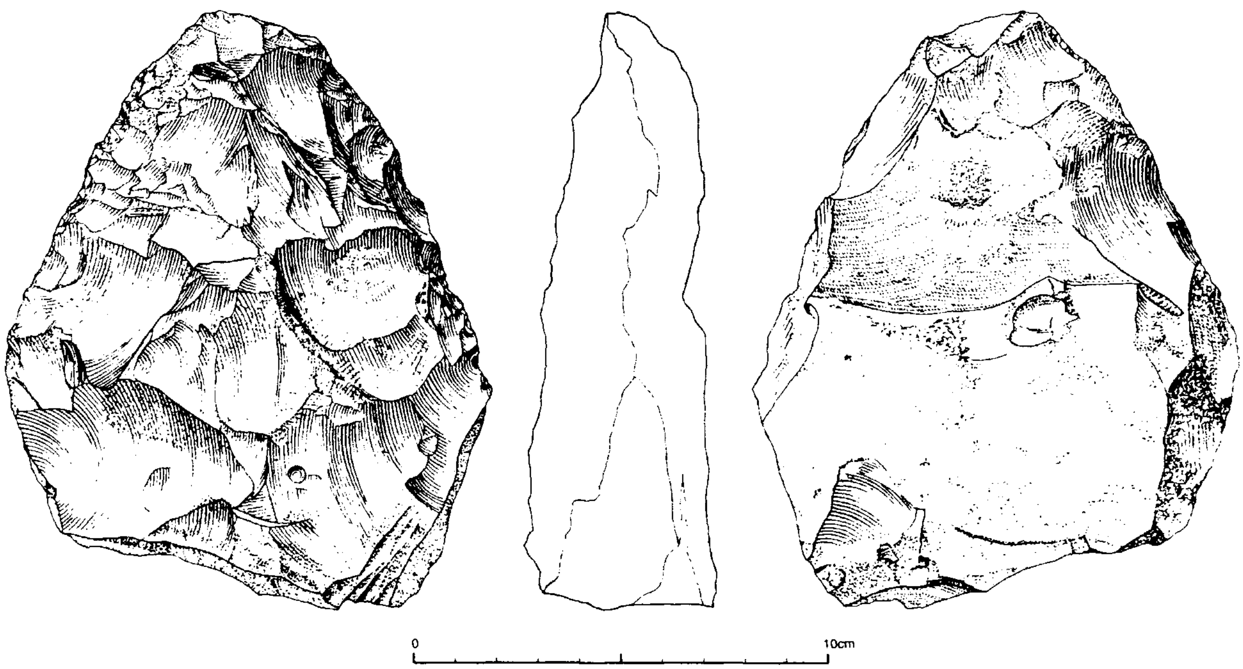


Fig 32.
1997.3-1.1. biface roughout from Area III black clay.

that emerge from study of the bifaces and biface roughouts (Figs 31–4). It is clear that roughouts are numerically far more important than the bifaces, suggesting that finished bifaces were generally taken away from the areas. This is particularly notable for the Area III black clay, where there were a large number of soft hammer flakes, four roughouts (eg, Fig. 32; 1997.3-1.1), but a complete absence of finished bifaces. In most cases it is apparent why the roughouts were discarded at a particular stage of manufacture, with breaks being frequent, usually as part of the knapping process. This was also the case with the finished, but broken biface tip (Fig. 31a; 1998.8-4.1).

Of the two complete bifaces that were left in the areas, both are generally ovate in shape, a feature that is reflected in some of the roughouts. This also conforms to the old collections which are dominated by ovates, sometimes with s-twists (Paterson & Fagg 1940). This latter feature is found on one of the complete bifaces from the current excavations (Fig. 33a; 1995.1-2.532). White (1998b) has tentatively suggested that the s-twist might be a significant feature of British biface assemblages attributed to MIS 11. Elveden would certainly support this suggestion.

The most unusual biface is 1996.3-3.1 (Fig. 33b). A knapping error seems to have led to a slight shoulder on one side of the base of the biface. For whatever reason, perhaps aesthetic, the knapper created a shoulder on the other side of the base, restoring the symmetry to the piece.

DISCUSSION
(NA, SL AND SP)

SPATIAL PATTERNING OF ARTEFACTS

There is a lack of evidence of spatial patterning of the artefacts within the archaeological areas. Even in Area III, where patterning might be expected, there was little obvious clustering of artefacts, and no obvious patterning in the distribution of cores or of hard hammer and soft hammer flakes.

Interpretation of spatial patterning between the areas, is dependant on their contemporaneity. It seems likely that the archaeological assemblages are broadly contemporary. Direct contemporaneity cannot be demonstrated. However, the gravel and black clay, from which all the artefacts are argued to originate, could have been forming at the same time. Stratigraphically they are distinct, but

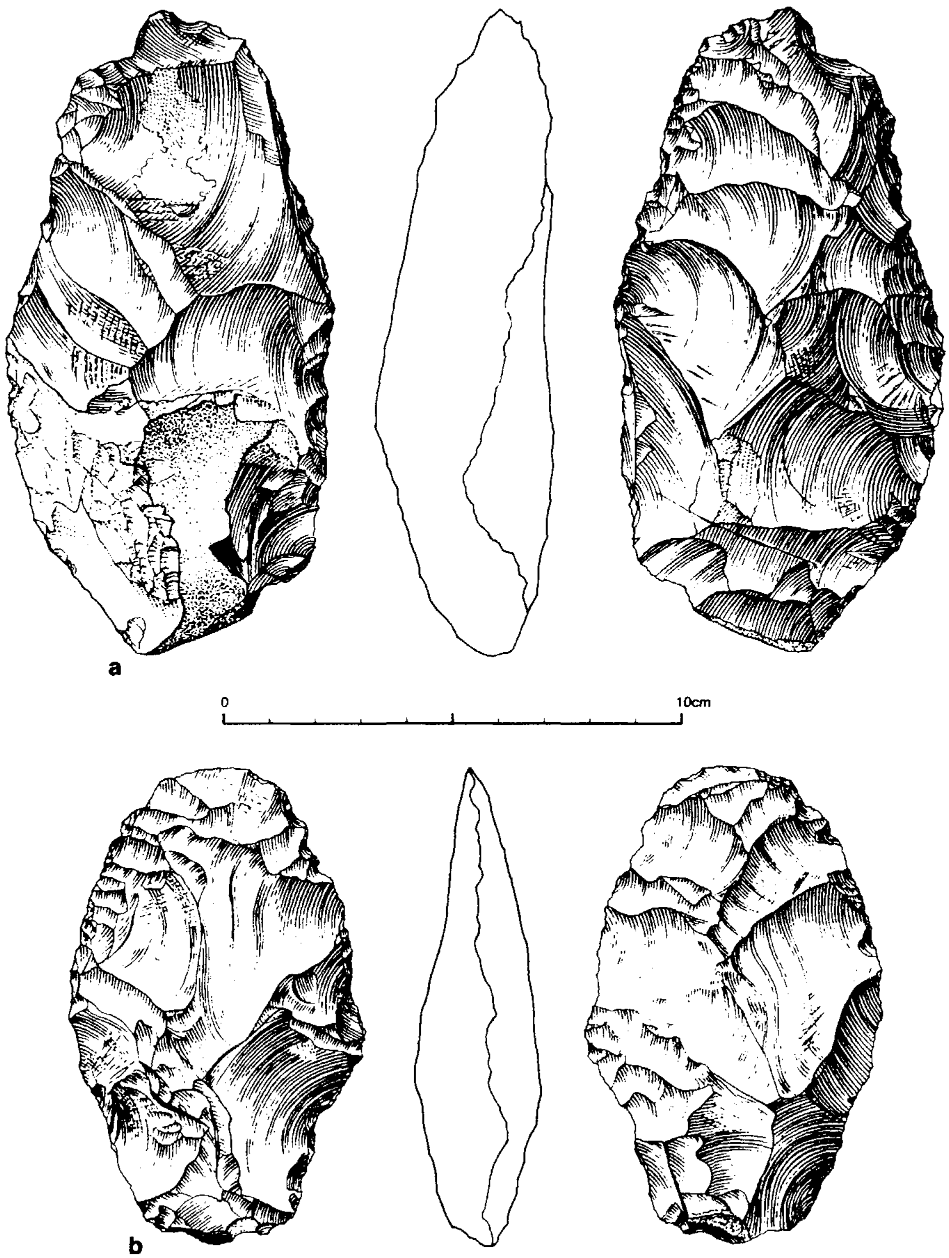


Fig 33.
a. 1995.1-2.532. biface from Area I rolled assemblage; b. 1996.3-3.1. biface from Area II gravel. (see Table 15).

geomorphologically the palaeosol could have been forming in one area, as the gravel was exposed and periodically inundated in another.

Given these limitations, slight differences in function might be recognisable between Area I and Area III (black clay horizon). In Area I there is more emphasis on raw material procurement, testing of nodules and roughing out of cores and bifaces, whereas in Area III, cores seem to have been brought into the area and there is greater emphasis on biface manufacture. Other than these slight differences, all areas provide a generalised picture of raw material

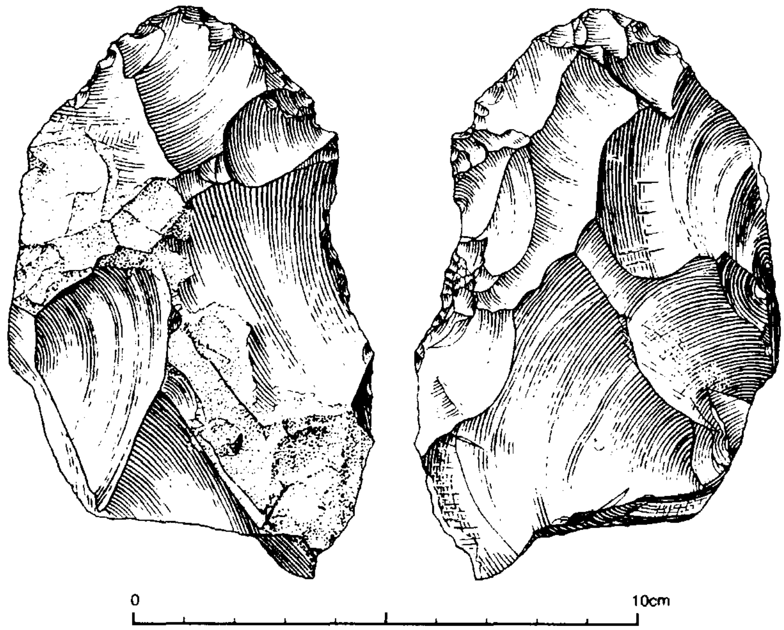


Fig 34.
1999.8-3.47. biface roughout from Area III brickearth.

procurement, biface, flake and flake tool manufacture.

HUMAN ENVIRONMENT

The generalised picture of human activity at Elveden can be given greater focus through an understanding of the context in which the archaeology occurs, but also where it is absent. The environmental evidence from the grey silt/clay reflects a changing landscape. The pollen from the lower part of this sediment indicates cool conditions with open vegetation growing in damp, poorly drained, base-rich soils at the edge of a water body. Borehole evidence also suggests that the basin was enclosed at this time forming a small lake. Whether or not this lake was fed by ephemeral streams is not known. The fauna in the upper part of the grey silt/clay shows a change in landscape and climate. The evidence suggests that the sediment was laid down by slow-flowing water in a wooded, temperate environment. Even if the lake still survived it was certainly fed and drained by streams during this phase.

Human artefacts appear to be absent from the lower and upper parts of this sediment. For the lower part of the grey silt/clay this might be because sampling was undertaken only in the centre of the basin, and the absence of equivalent deposits on the edges of the basin. However, the upper part of the grey silt/clay was more extensively sampled in the centre of the basin, and also in sections around the edge in Areas I, III, IV, and V. The absence of humans at the site, at least during the later phase, appears to be a real phenomenon.

The first evidence of humans at the site is when a river, with a sufficiently strong current to create a lag gravel, became established at the site. The reasons for this change in human presence are probably twofold. During the earliest post-glacial phase at the site the small pocket of water is likely to have been a remote and obscure part of the landscape. Gradually the streams that fed and drained the lake became better established, so that by the time humans are first in evidence at the site, the river would have formed an important corridor through an otherwise wooded landscape. The river also contributed to the creation of an accessible raw material source, through both the erosion of Chalk, but also in forming the lag gravel.

The artefacts from the 'brickearth' are argued to have been derived from the underlying gravel. If this interpretation is correct, then human activity ceased at the site once the lag gravel was covered and the river dried up.

This focus of human activity in riverside locations appears to be the case at other sites. The earliest post-Anglian phase at Barnham is represented by sediments in an enclosed basin, and again humans appear to be absent (Ashton *et al.* 1998). Equally at Hoxne, humans are only evident at the site, once a river has been established, after the infilling of the lake basin (Ashton *et al.* in prep.). The same may be true of Marks Tey, where there is only limited evidence so far of human occupation associated with a gravel on the lake margins. It is not clear, though, how this gravel relates to the lake sequence.

Access to raw material is probably the key to understanding this pattern, although rivers would also have been a focus for other activities and provided a range of other resources. They gave access to water, feeding and watering game, and a more diverse range of plant resources. If the interfluves were heavily wooded, as seems likely, the river valleys would have provided natural corridors through the landscape, kept open by the foraging and trampling of large mammals.

It is important, of course, to be cautious of misusing the absence of evidence. Does the recognition of human presence at a site merely reflect the distribution of raw material resources and their use? At Elveden this question cannot be answered, but at other sites it possibly can. At Hoxne the Lower Industry was recovered from the edge of a fluvial channel, but with no obvious source of raw material nearby (Singer *et al.* 1993; White 1998a; Ashton *et al.* in prep.). Equally at High Lodge, the assemblage from Bed C was recovered on a floodplain in overbank sediments, without any evidence for the source of raw material (Ashton *et al.* 1992). The same is true of the industry from the Lower Loam at Swanscombe (Conway *et al.* 1996). All these sites show that rivers were favoured locales, but not simply for the stone raw materials that they sometimes provided. They also suggest that wherever humans were present, they were prone to leaving large quantities of litter behind, whether or not they were encamped on a raw material source.

ELVEDEN AND BARNHAM

The correlation of the temperate episode represented at Elveden with the Hoxnian (MIS 11) also indicates time-equivalence with the interglacial deposits at East Farm, Barnham. As noted above this is contrary to the interpretation of Paterson and Fagg (1940), but there are compelling reasons for equating Elveden and Barnham. If this broad correlation is accepted, it is then possible to look in more detail at the stratigraphy of these sites and to consider to what extent they record similar depositional and palaeoenvironmental conditions. The most striking common elements are:

- fine-grained sediments infilling a depression in the basal chalky diamicton,
- initially a standing water body, giving way to fluvial conditions,
- accumulation of fine-grained sediments during the first part of the interglacial climate cycle,
- cessation of fluvial activity, formation of a palaeosol on a stabilised landsurface,
- similar range of archaeological assemblages in a similar range of sediments.

Attempts were made during the current fieldwork to find direct links between the two sites through a combination of examining intervening pits, coring and through geophysics. The gravel at Barnham lies at approximately 35 m OD, about 5 m lower than the gravel at Elveden. Unfortunately the 7 km of intervening land between the sites drops well below the 35 m contour. This suggests that if there had been a direct link between the sites any evidence of this link has been eroded away.

The similarities between the sites do not necessarily indicate that the sediments were once continuous between the two. Rather they suggest that sedimentation at both sites was responding to the same controlling influences. Initially the sites would have formed as isolated hollows on the newly deglaciated, till-covered landscape. Such hollows are numerous across East Anglia; many contain sediment laid down under temperate climate conditions, and probably reflect the discontinuous nature of the drainage network immediately following deglaciation. The switch to a fluvial depositional environment may reflect the establishment of a drainage network and the linking together of these isolated water bodies. The fish assemblage from Barnham suggests linkage to a major river network and contains migratory species such as salmonids (Irving & Parfitt 1998). The reasons for the demise of the fluvial environment at Elveden and Barnham are unclear. Changes in the regional hydrology, resulting from reduced precipitation and/or increased evaporation may have caused a reduction in surface water flow. Alternatively the progressive removal of the impermeable till cover by fluvial erosion may have led to increased infiltration and reduced surface run-off and the formation of a dry valley network. Both Elveden and Barnham are located in dry valley situations at the present time. The reduction in surface flow led to stabilisation of the land surface and soil formation. This was followed by dominantly colluvial deposition at both sites, punctuated by phases of stability and incipient soil formation (see above; Kemp 1998).

If the interpretation offered above is correct, then it is likely that the human activity at Elveden was at least contemporary within the resolution of the geology with that at Barnham, although actual contemporaneity cannot be positively demonstrated. All the assemblages occur in the same set of deposits at the two sites, primarily the lag gravel and the overlying black clay. Barnham almost certainly lay on the same drainage system, if not the same river, as Elveden, and lying only 7 km to the east would have been within a two hour range.

At Barnham it was argued that different activity areas could be identified, with some locations concentrating on core and flake working, and others on different stages of biface production. At Elveden it is more difficult to identify areas of this kind. As shown above, the range of technology is very similar to Barnham, although it seems that there was a greater emphasis on biface production. This might relate to the proximity of flint from the Chalk at Elveden, and the reliance on gravel flint at Barnham. Whether it was literally the same people at the two sites, or whether they were several generations apart, it is still possible to build a picture of human use of a landscape that stretched over several kilometres within a single or related river valley.

ELVEDEN, NON-BIFACE ASSEMBLAGES AND THE CLACTONIAN

One of the curious features of the assemblage in Area I is the low quantity of rolled soft hammer debitage. The fact that it is present at all indicates that bifaces were being made, but possibly in small numbers. The interpretation offered above is that much of the soft hammer debitage has been winnowed away in the fluvial environment. This proposition can be tested by examination of other excavated biface assemblages from fluvial sands and gravels. In these assemblages an under-representation of soft hammer flakes might also be expected.

Unfortunately for Britain, there are only three such assemblages. These are the 1968–72 excavation by Waechter of the Lower Middle Gravels at Swanscombe (Conway *et al.* 1996), the 1962–8 excavation by Sieveking of Bed E at High Lodge (Ashton *et al.* 1992), and the 1955–60 excavation by Wymer of the Upper Middle Gravel at Swanscombe (Wymer 1964). The latter was primarily dug through bedded sands. Only 2000 flakes were kept from the original tally of 8147, but it is clear from the report that they came from a specific area and therefore should be representative of the whole assemblage.

Table 16 shows the percentages of soft hammer and hard hammer flakes in all three assemblages, compared to the rolled assemblage from Elveden Area

TABLE 16 PERCENTAGES OF SOFT HAMMER AND HARD HAMMER DEBITAGE IN DIFFERENT SEDIMENT TYPES

	no. of flakes	*sediment*	*Soft hammer flakes*	*Hard Hammer flakes*
Elveden Area III Black clay	382	clay	42	58
Elveden Area I rolled	214	gravel	5	95
Swanscombe, Lower Middle Gravel	122	gravel	2	98
Swanscombe Upper Middle gravel (C/D)	198	sand	8	92
Swanscombe Upper Middle Gravel (E)	1353	sand	7	93
High Lodge Bed E	384	gravel	4	96

I and the largely undisturbed assemblage from Elveden Area III. It is clear that soft hammer flakes from all the sand and gravel contexts are massively under-represented. These figures support the interpretation that fluvial winnowing can have an important impact on soft hammer representation within assemblages.

This observation has important implications for how we interpret assemblages from gravel and sand contexts. The absence of soft hammer debitage does not necessarily imply that bifaces were not being made. This is yet another factor to be considered when addressing the problem of whether non-biface assemblages can be attributed to the Clactonian. The definition of the Clactonian as a cultural group who neither made nor used bifaces, suffers by its reliance on the absence of evidence. This has allowed a range of other arguments to be deployed to provide alternative explanations. In the literature over the last 25 years these have included the influence of raw material, the role of site function, the problems of small sample size, and the disputed presence of bifaces in old Clactonian collections. (For a full review see White 2000). To this list should now be added the problem of taphonomy.

Elveden also has a bearing on the stratigraphic relationship between biface and non-biface assemblages. Given the problems over the definition of the Clactonian, a clear chronological separation of biface and non-biface assemblages would be strong support for the cultural interpretations.

Recent work at Beeches Pit has shown a change in the dominance of particular species of molluscs (Preece *et al.* in prep.; Preece & Penkman in press). This change can be linked to similar changes at Swanscombe and at Barnham. The land mollusc, *Discus ruderatus*, is predominant in Bed 3b at Beeches Pit, whereas *D. rotundatus* is significantly more numerous in the overlying Bed 4. A similar change in the dominance of these species is probably recognisable at Swanscombe, where *D. ruderatus* is common in the Lower Loam at Barnfield Pit, and *D. rotundatus* dominates what is thought to be the

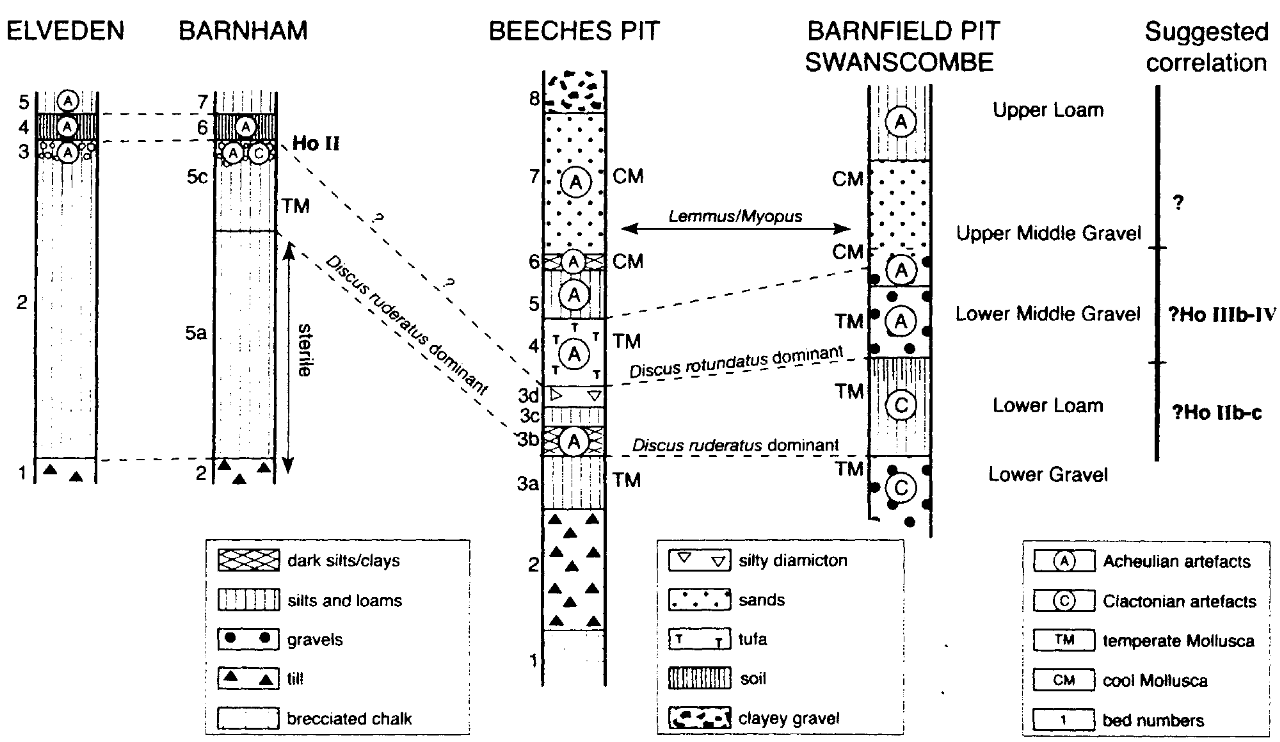


Fig 35.
Correlation between Elveden, Barnham, Beeches Pit and Swanscombe (based on Preece *et al.* in prep., courtesy of Richard Preece).

equivalent of the Swanscombe Middle Gravel in the shell bed at the nearby site of Dierden's Pit in Ingress Vale. *D. ruderatus* is also dominant at Barnham in Unit 5c which is argued to be contemporary with the archaeology at the site (Ashton *et al.* 1998).

These correlations are shown in Figure 35 together with the lithostratigraphic correlation of Barnham with Elveden, and also with the type of assemblages that have been found in the different units at each of the sites. This suggests that both biface and non-biface assemblages can be correlated with HoIIb-c. Although this is a vegetation phase that probably lasted several thousand years, it shows that if different human groups are represented by the different assemblage types, then they inhabited similar niches in the landscape with a similar climate. Without better resolution of the stratigraphy, it cannot be determined whether the groups would have been directly contemporary. If a convincing chronological separation between the assemblage types could be demonstrated and with a bigger array of sites, then the arguments for distinct cultural traditions would be far more persuasive.

SUMMARY

The site at Elveden consists of a sedimentary basin within the Chalk, which is mantled by Lowestoft till (bed 1) attributable to MIS 12 (Fig. 36). The basin is infilled with fine-grained sediments (bed 2). Pollen from the lower part of these sediments indicates cool, open conditions, whereas the fauna from the upper part of these sediments show a fully temperate climate. Although the basin was initially closed, towards the top of the sequence there is evidence of increased water flow through the area. The fauna and AAR ratios are consistent with bed 2 being

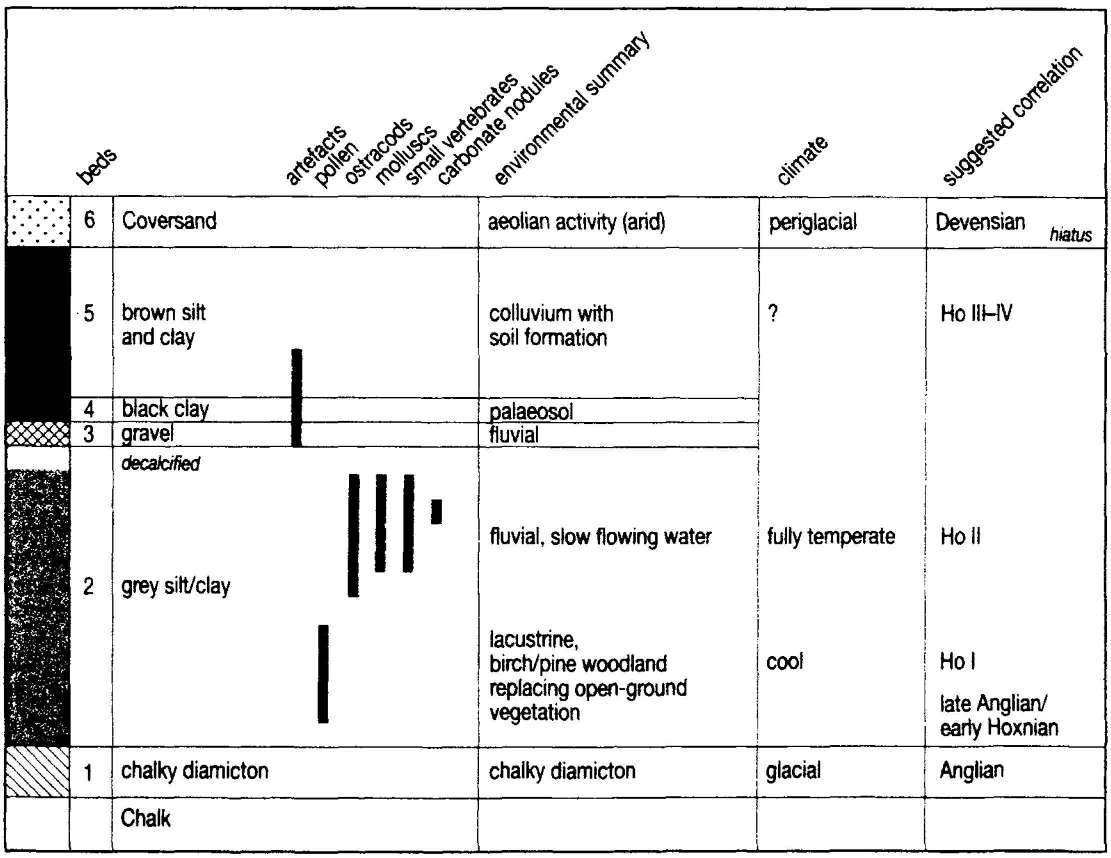


Fig 36.
Summary of the lithological, environmental, and archaeological data from Elvedon

attributable to MIS 11. Also of significance is the presence of the ostracod *Ilyocypris quinculminata*, which is not found in deposits younger than MIS 11. The overlying lag gravel (bed 3) shows the establishment of a river and the first evidence of human activity at the site. As the basin dried out a black clay (bed 4) immediately overlying the gravel, showed the development of soils at the margins of the water body. Artefacts in primary context were contained within the fluvial sediment on which the soil was developed. Further infilling of the basin by colluviation is shown by the 'brickearth' (bed 5) which also shows the formation of a complex series of soils. Artefacts from the lower part of this unit were probably derived from the underlying lag gravel. The sequence is overlain by Devensian coversand (bed 6).

The artefactual evidence shows that humans were procuring flint from both the nearby Chalk and from the lag gravel for the manufacture of bifaces, together with flakes and occasionally scrapers and notches from cores. This activity took place in a series of broadly contemporary sediments at the edges of a river channel surrounded by woodland in a temperate climate. The absence of artefacts from the lower lacustrine sediments, together with evidence from other sites, suggests that humans favoured fluvial environments, where a greater array of resources were available and the valleys provided open corridors through the otherwise wooded landscape.

The similarity of the stratigraphy, the environmental evidence and the dating to the nearby site of East Farm, Barnham, suggests that the human activity at the two sites was broadly contemporary and that they were probably part of the same drainage network. The greater emphasis on biface manufacture at Elveden, compared to Barnham, may be related to the better access to flint more directly derived from the Chalk at Elveden. The much larger faunal assemblages from Barnham allow tentative correlation with other sites. In particular, the dominance of *Discus ruderatus* over *D. rotundatus* at Barnham suggests correlation with one of the biface assemblages at Beeches Pit, but with the non-biface assemblage in the Lower Loam at Swanscombe (Preece *et al.* in press; Preece & Penkman in press). Although this does not necessarily indicate that biface and non-biface assemblages are contemporary, it does suggest that they both occur in the same vegetational and climatic zone of the Hoxnian.

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APPENDIX I. FLAKE MEASURES AND INDICES. KEY TO TABLES 12 AND 14

Cortical index. The index is $(x_1 \times 1) + (x_2 \times 0.67) + (x_3 \times 0.33)$, where xn is the percentage of cortex category n. Categories are: 1. wholly cortical; 2. > 50% cortex; 3. < 50% cortex; 4. no cortex.

Relict core edges. Where a part of a core edge, showing negative bulbs of percussion, is preserved on a flake, this is termed a relict core edge. They can be divided up into two main types: types 1–3 where the core edge is preserved on the dorsal of the flake and forms part of a separate sequence to that flake; and types 4–6 where the core edge is on the butt of the flake. They are used to support the evidence of flaking from the cores.

1. Parallel flaking on the dorsal. Two or more flake scars indicating parallel removals from a single or adjacent platforms.
2. Simple alternate flaking on the dorsal. A sequence of flake scars showing that one or more removals formed the platform for one or more further removals.
3. Complex alternate flaking on the dorsal. Similar to 2, but showing evidence of at least one more turn of the core.

4. Parallel flaking on the butt. Similar to 1, but the flake scars indicate removal from the same platform as the actual flake, that flake being the last removal in that sequence.
5. Simple alternate flaking on the butt. Similar to 2, but the sequence is positioned on the butt, with the actual flake forming the last removal in the sequence.
6. Complex alternate flaking on the butt. Similar to 3, but the sequence is positioned on the butt, with the actual flake forming the last removal in the sequence.

Dorsal scar patterns. These indicate the direction of previous flake removals on the dorsal face.

1. Flakes removed from proximal end only.
2. Flakes removed from proximal and left only, or proximal and right only.
3. Flakes removed from proximal, left and right.
4. Flakes removed from proximal, distal and right only, or proximal, distal and left only.
5. Flakes removed from either left only, or right only.
6. Flakes removed from distal.
7. Flakes removed from proximal and distal.
8. Flakes removed from right and left.
9. Flakes removed from proximal, right, left and distal.
10. Dorsal wholly cortical or natural.
11. Flakes removed right, left and distal.
12. Flakes removed from distal and right only, or distal and left only.

The distal index is the combination of percentages of dorsal scar pattern types 4, 6, 7, 9, 11 and 12. It is a measure of the amount of flaking from the distal end.

Scar index. This index is calculated from the percentages of flakes with x number of scars. Thus the Scar Index = $\sum xp_x /10$ where x is the number of dorsal scars and p is the percentage of each dorsal scar frequency. The higher the index, the higher the number of scars on the flakes in the assemblage. For the table below the scar index is:

$[(6x0) + (9x1) + (30x2) + (35x3) + (16x4) + (4x5)] / 10 = 25.8$

No. scars	0	1	2	3	4	5
%	6	9	30	35	16	4

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